The Impact of Mental Health, Physical Health, and Illness Perceptions on Physical Activity in a COPD Population

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By

Karla Horvey

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Abstract

Purpose – This body of research exists to expand the knowledge base surrounding how mental health, physical health, and illness perceptions interact with physical activity levels in individuals with COPD.

Methods – The first study looked at pulmonary rehabilitation participants and consisted of measuring physical activity, anxiety, depression, and illness perceptions on entry to the program and again, after three months of participation in the program. The second and third study were both completed with data collected from Statistics Canada (Canadian Health Measures Survey). In the second study, information from across Canada was analyzed to determine correlates with physical activity for all levels of airway obstruction severity separately and together (self-reported health, mental health, quality of life, respiratory symptoms, spirometry). The third study took similar variables and compared them between those who had obstruction and those withoutas well as between each separate level of airway obstruction (mild, moderate, severe/very severe).

Results – The first study found that as anxiety levels increase, health related quality of life (HRQoL) gets worse and typical dyspnea levels are elevated. As depression levels increase, both exertional and typical dyspnea increase, HRQoL decreases, and illness perceptions become more negative. These more negative illness perceptions are related to increased exertional dyspnea and lower HRQoL. The second study found that there were several common variables that helped predict all intensities of physical activities at various levels of airway obstruction: self-perceived health, mental-health, QOL, life satisfaction, simple chores make SOB, wheeze on exertion, and frequent persistent colds. The third study found that, in general, as airway obstruction increases, physical activity levels decrease along with self-perceived health, stress, and quality of life. Respiratory symptoms also increase as obstruction increases. Physical activity levels were not significantly different between those with airway obstruction and those without obstruction.

Significance of Findings – Individuals with moderate to very severe obstruction had lower levels of physical activity than their healthy counterparts. These reductions in physical activity levels may be related to the sensation of dyspnea, lower levels of quality of life, poor perceived health/mental health, higher levels of anxiety and/or depression, and the presence of more negative illness perceptions.

Preface and Author Contributions

I, Karla Horvey, was the primary author of all chapters within this thesis. Chapters two through four represent manuscripts that are to be submitted for publication in peer-reviewed journals. Chapters two, three, and four are co-authored by Dr. Lawrence Brawley, Dr. Donna Goodridge, Dr. Joshua Lawson, Dr. Darcy Marciniuk, and Dr. Scotty Butcher. The analyses completed for chapters three and four were completed on the same populations but with different goals in mind. The research questions used in all three studies were developed by myself, with guidance from my advisory committee. The data analysis was completed by myself with guidance from Dr. Joshua Lawson and Dr. Scotty Butcher. The interpretation of the data along with review of the manuscript was completed by myself with guidance from Dr. Lawrence Brawley, Dr. Donna Goodridge, Dr. Joshua Lawson, Dr. Darcy Marciniuk, and Dr. Scotty Butcher.

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List of Common Abbreviations Used

ADO index – age, dyspnea, airflow obstruction

AECOPD – Acute Exacerbation of COPD

ANOVA – Analysis of Variance

BIPQ – Brief Illness Perception Questionnaire

BODE index – Body mass index, airflow obstruction, dyspnea, and exercise

CHMS – Canadian Health Measures Survey

COPD – Chronic Obstructive Pulmonary Disease

CPET – Cardiopulmonary Exercise Test

DSM-IV – Diagnostic and Statistical Manual of Mental Disorders, 5th Edition

FEV_1 – Forced Expiratory Volume in One Second

FVC – Forced Vital Capacity

GOLD – Global Initiative for Chronic Obstructive Lung Disease

HADS – Hospital Anxiety and Depression Scale

HRQoL – Health Related Quality of Life

MBQOA – Modified Baecke Questionnaire for Older Adults

mCAFT – Modified Canadian Aerobic Fitness Test

METs – Metabolic Equivalents

MRC – Medical Research Council

PA – Physical Activity

PR – Pulmonary Rehabilitation

PFT – Pulmonary Function Test

QOL – Quality of Life

RDC – Research Data Centre

SGRQ – St. George's Respiratory Questionnaire

SOB – Shortness of Breath

VMU – Vector Magnitude Units

6MWT – 6 Minute Walk Test

6MWD – 6 Minute Walk Distance

Chapter 1 – Introduction and Literature Review

1.1 Background

Chronic obstructive pulmonary disease (COPD) is a common respiratory disease that impacts a large number of Canadians both physically and mentally. Having a chronic disease such as COPD can decrease an individual's physical activity level, increase levels of anxiety and depression, decrease quality of life, and can result in negative views on how their disease impacts their lives. All of these issues can potentially also have an effect on each other to change the experience of a person living with COPD. This chapter will discuss previous research into the above areas as well as outline deficient areas that can be filled by research completed for this PhD.

1.1.1 Diagnosing COPD

Chronic obstructive pulmonary disease is a progressive respiratory ailment, primarily affecting smokers and is characterized by partially reversible obstruction of the airways (O'Donnell et al, 2008). It is diagnosed by spirometry showing a forced expiratory volume in one second (FEV_1) to forced vital capacity (FVC) ratio of less than 0.70 (O'Donnell et al, 2007). There are 4 levels of severity in COPD: mild ($FEV_1 \geq 80\%$ predicted), moderate ($50\% \leq FEV_1 < 80\%$ predicted), severe ($30\% \leq_1 < 50\%$ predicted), and very severe ($FEV_1 < 30\%$ predicted) (O'Donnell et al, 2007) with obstruction worsening as disease severity increases.

1.1.1.1 Spirometry

Spirometry is a test used to diagnose COPD and other respiratory ailments. It measures inhaled and exhaled volumes and the time it takes to complete inhalation and exhalation with values being expressed as volume or flow (Miller et al, 2005). The performance of spirometry is completed in 3 phases: a maximum inhalation, a forced exhalation (hard and fast), and a continuation of this exhalation until the end of the test (Miller et al, 2005). From this test, the FEV_1 indicates the maximum volume of air that can be forcibly expired in the first second of a maximum exhalation following a maximum inhalation (Miller et al, 2005). The FVC is the total amount of air that can be forcefully exhaled after a maximum inhalation (Miller et al, 2005). The FEV_1/FVC is the ratio of the aforementioned values and when this number is below 0.70 it indicates the presence of airway obstruction, likely in the presence of COPD (O'Donnell et al, 2007). Since there is variability in an individual's performance of spirometry, there needs to be three consistently reproducible efforts made in order to accept the spirometry values where the FVC and FEV_1 values are within 0.150 L of each other (Miller et al, 2005).

In order to differentiate COPD from other airway obstruction, spirometry needs to be completed both before and after the administration of a short acting bronchodilator (Miller et al, 2005). This determines if there is an aspect of reversibility to the obstruction. The subject completes their spirometry as described above when they have not taken a short acting bronchodilator within the past 4 hours. The bronchodilator is then administered and approximately ten minutes later, the subject completes three more satisfactory and reproducible spirometry manouevers for comparison to the previous three (Miller et al, 2005). COPD is the likely diagnosis if there is less than a 12% improvement in FEV_1 after bronchodilator administration (Lougheed et al, 2012).

1.1.2 Pathophysiology of COPD and Exercise Limitations

Traditionally, COPD has been separated into two phenotypes: chronic bronchitis and emphysema. Chronic bronchitis is characterized by obstruction due to airway inflammation and increased secretions while emphysema is characterized by destruction of connective tissue especially in the alveoli leading to air trapping and poor gas exchange (MacNee et al, 2016). In recent years, it has been found that there are more likely to be four phenotypes in COPD: predominant emphysema, predominant chronic bronchitis, frequent exacerbators, and COPD with significant reversibility (Magnoni et al, 2014).

Airway obstruction is generally presented mostly as expiratory flow limitation due to physiological changes in the lungs leading to hyperinflation and air trapping (O'Donnell et al, 2008). This presents as increased airway resistance starting in the peripheral airways and includes inflammation and even destruction of these airways (Hogg et al, 1968) as well as increased secretion of mucous (Hogg et al, 2004). Chronic inflammation impacts both the central and peripheral airways as well as the pulmonary vasculature, alveoli, and parenchymal tissues (Mitchel, 2015). There is also an increase in mucous production due to both a larger number and increased size of goblet cells in the airways (Mitchel, 2015). Pulmonary hypertension can occur secondary to changes in the pulmonary vasculature (Mitchel, 2015), further complicating the respiratory changes. These changes, along with a decreased lung elastic recoil, result in progressive dyspnea, leading to limitations in physical activity levels (O'Donnell et al, 2014). Because of this loss of elastic recoil, airway remodelling, and decreasing FEV_1, airway obstruction becomes not fully reversible (Mitchel, 2015).

The limitations in physical activity are a response to high ventilatory requirements, compromised pulmonary mechanics, dysfunction of skeletal muscle, as well as cardiovascular issues and leads to a reduced peak oxygen uptake during exercise (Chin et al, 2013; Guenette et al, 2011). Higher levels of trapped air in combination with decreased lung compliance during physical activity lead to both tachypnea and an expiratory flow limitation – this results in insufficient time to reach end-expiratory lung volume, leading to dynamic hyperinflation and dyspnea (Chin et al, 2013). As COPD progressively worsens, exercise limitation becomes more pronounced with an increased respiratory drive coming from the central nervous system (Laveneziana et al, 2007) along with a mechanical constraint placed on the respiratory system and a reduction in resting inspiratory capacity (O'Donnell et al, 2006; O'Donnell, 2012). It has also been found that there are issues with ventilation/perfusion mismatching due to mucous plugging and distortion of the small airways (Rodriguez-Roisin et al, 2009; Wagner et al, 1977). However, it has been found that the ratio of inspiratory capacity to total lung capacity along with dyspnea levels can predict the decline in exercise capacity that is seen in COPD (Ramon et al, 2016).

1.1.3 Prevalence of COPD

In Canada, it is estimated that 17% of the population from a nationwide sample 35-79 years of age have obstructed airflow consistent with pre-bronchodilator FEV_1/FVC values of less than 0.70 (Evans et al, 2014). When using lower limit of normal as a cut off instead of a fixed-ratio (0.70), it was found that 12% of Canadians in this age group have spirometry indicative of COPD (Evans et al, 2014). This data was confirmed in a second nation-wide study (Canadian Cohort of Obstructive Lung Disease [CanCOLD] study) on individuals aged 40 years and older that approximately 17% of Canadians meet the criteria for COPD when measured by fixed-ratio cut offs (0.70) while 11% meet the criteria with lower limit of normal criteria (van Dijk et al, 2015). Evans and colleagues (2014) found that only 39.6% of those who had spirometry indicative of COPD had an actual diagnosis of COPD from a physician while 30.2% had a diagnosis of chronic bronchitis. This may mean that COPD could potentially be underdiagnosed in the Canadian population. The CanCOLD study also revealed that 29% with spirometry indicative of COPD had never been a smoker and that this diagnosis was associated with an older age and history of asthma (Tan et al, 2015). The 71% of those in the CanCOLD study who had ever been a smoker had their diagnosis predicted by older age, more than 20 pack years of smoking history, and asthma diagnosed by physician (Tan et al, 2015). It has also been estimated that the prevalence of COPD in Canada will increase as the population of older adults increases. Najafzadeh and colleagues (2012) project that by the year 2035, the number of COPD patients in Canada will rise to 5.83 million from 3.45 million in 2011.

1.1.4 Burden of COPD

Since the number of Canadians with COPD is expected to rise in the next several decades, the burden on society associated with COPD is also expected to increase (Najafzadeh et al, 2012). It is estimated that between 2011 and 2035, there will be a 101.4 billion dollar cost to Canadian society from COPD with this cost of COPD being most sensitive to number of acute exacerbations, population growth, and risk of previous smokers developing COPD (Najafzadeh et al, 2012). The number of comorbidities present in those with COPD also helps to predict the number of emergency department visits, and therefore cost to society with a larger number of comorbidities being associated with increased emergency department visits (Mannino et al, 2015). Along with having a higher number of comorbidities, individuals with COPD have more hospital admissions, readmissions, a longer length of hospital stay, and a higher in-hospital mortality rate when compared to age-matched controls (Baty et al, 2013).

1.2 COPD and Physical Activity

Physical activity is considered to be activity which is a natural part of an individual's day and is not considered to be formal exercise, although exercise may help to accumulate physical activity time and/or steps during the day. It can be measured in steps per day or minutes per day. These minutes per day can be broken down into various levels of intensity depending on how many vector magnitude units (VMU) are being recorded by an accelerometer or by subjective measurement if an accelerometer is not available. It has been well documented that individuals with COPD have decreased physical activity levels compared to those without COPD (Vorrink et al, 2011; Pitta et al, 2005; Amorim et al, 2014; Chambaneau et al, 2016; Eliason et al, 2011; Kawagoshi et al, 2013; Mador et al, 2011; Nguyen et al, 2011; Hartman et al, 2013) with these changes occurring prior to even having an official diagnosis of COPD (van Remoortel et al, 2013). This occurs with both slow walking time and fast walking time, and even the number and frequency of postural changes is decreased in those with COPD compared to healthy adults (Kawagoshi et al, 2013). Healthy individuals who identify as having a Medical Research Council (MRC) dyspnea scale grade 2 with activity compared to individuals with COPD with the same level of shortness of breath have higher levels of daily physical activity, despite similar self-reported dyspnea (Johnson-Warrington et al, 2014). All intensity levels of physical activity are reduced in the COPD population compared to healthy controls (Minakata et al, 2014). Having the chronic bronchitis phenotype gives even higher levels of dyspnea and lower levels of physical activity compared to both healthy controls and those with non-chronic bronchitis COPD (Elbehairy et al, 2015). Level of dynamic hyperinflation has also found to be associated with activity level, regardless of disease severity (Garcia-Rio et al, 2009). As disease severity increases, physical activity levels decrease along with a progressive decline in lung function (Waschki et al, 2015; Demeyer et al, 2016; Pitta et al, 2005; Blumenthal et al, 2016; Belza et al, 2001; Jehn et al, 2011; Nguyen et al, 2011; Steele et al, 2000).

1.2.1 Physical Activity, COPD, and Physical Health

In the general population, lower physical activity levels tend to be associated with older age with females having lower levels than males and those living in a high-income country having lower levels than those in a low-income country (Hallal et al, 2012). Living in a low socioeconomic area is related to lower physical activity levels, likely because of a perceived lack of safety for outdoor activities (Meyer et al, 2014). Those who meet recommended physical activity levels tend to have better health related quality of life in the form of both physical and mental health (Hart, 2016). Regular participation in physical activity helps prevent cardiovascular disease, coronary artery disease, type 2 diabetes, and obesity as well as being negatively correlated with osteoporosis, colon cancer, depression, and anxiety (Kesaniemi et al, 2001).

Physical activity levels in individuals with COPD are associated with a multitude of factors, with disease severity being only one of them. Having multiple physical comorbidities alongside COPD is related to decreased minutes per day of physical activity (both light intensity and moderate intensity) and increased time spent in sedentary behaviours as compared to those with COPD alone (McNamara et al, 2014). Lower physical activity levels are also related to increased levels of fatigue, decreased exercise capacity, increased smoking rates (Todt et al, 2015), and presence of sarcopenia (Jones et al, 2015). These low levels of activity are also a predictor for frailty in those with stable COPD with the strongest frailty predictor for those in an acute exacerbation being shortness of breath (Valenza et al, 2016). Frailty has also been associated with lower gait speeds, meaning that walking speed can be used to screen for frailty in those with COPD (Mittal et al, 2016). A lower level of fat-free muscle mass has also been shown to be a predictor for physical inactivity (Waschki et al, 2015). Other characteristics relating to lower levels of physical activity include older age, female sex, and a higher socioeconomic status (Garcia-Aymerich et al, 2004).

There are a multitude of physical and systemic characteristics associated with COPD that are related to a lower than normal level of physical activity. Inflammatory markers have also been found to be related to physical activity with higher indicators of inflammation being associated with decreased physical activity (Loprinzi et al, 2014; Watz et al, 2008), meaning that physical activity may be used to mediate the effects of inflammation in COPD. Dynamic hyperinflation has been linked to a higher level of both systemic and airway inflammation in COPD (Zhang et al, 2015), providing a potential link between increased inflammation and decreased physical activity. Peak oxygen consumption (VO_2max) during maximal exercise tests is also reduced, alongside habitual physical activity levels (Elbehairy et al, 2015; Pitta et al, 2005). Level of breathlessness is a large factor in the prediction of physical activity levels in COPD with increased dyspnea (Demeyer et al, 2016; Steele et al, 2000) and/or air hunger leading to lower activity levels (Loprinzi et al, 2015). This may be due to progressive air trapping as disease severity increases (Loprinzi et al, 2015). Similarly, individuals with COPD who can increase their tidal volume while exercising and maintain an inspiratory reserve volume that is adequate will be more physically active (Kortianou et al, 2015). Participation in a regular physical activity program can help improve these dyspnea levels as well as overall exercise capacity (Miyamoto et al, 2014). People with COPD start to reduce their levels of physical activity earlier in life than sedentary healthy older adults and this early reduction in activity levels occurs prior to the onset of dyspnea with exertion (Gouzi et al, 2011). A lower self-reported functional status (Nguyen et al, 2011; Belza et al, 2001) and physical health status is also significantly related to a lower level of physical activity (Belza et al, 2001).

Physical inactivity has its own set of issues when it comes to health outcomes. Increased daily physical activity levels are related to a decreased use of short-acting bronchodilators and a decreased number of acute exacerbations resulting in hospital admissions (Katajisto et al, 2015).

This same study found that activity level was not related to decreased adherence to maintenance medications (Katajisto et al, 2015). An increased amount of low-intensity physical activity is beneficial at reducing risk of hospital admission for an acute exacerbation of COPD while an increase in high-intensity activity does not change the risk for hospitalisation (Donaire-Gonzalez et al, 2015). It has also been reported that any amount of moderate to vigorous activity is related to a lower readmission risk (Nguyen et al, 2014). Activity levels decrease while in hospital for acute exacerbation but subsequently improve shortly after discharge (Tsai et al, 2016; Chawla et al, 2014), but those who continue to have a decline in physical activity after discharge are more likely to be readmitted to hospital with another acute exacerbation (Chawla et al, 2014). The changes in physical activity levels while in hospital for an acute exacerbation can be predicted by previous level of activity prior to exacerbation, age, quality of life, living alone, hospital length of stay, as well as which medications were used in treating the exacerbation (Esteban et al, 2016). Even those exacerbations not resulting in a hospital stay are associated with a reduction in physical activity levels with a larger decrease being related to a more lengthy recovery from the exacerbation (Alahmari et al, 2014). More frequent exacerbations are also related to a quicker deterioration in physical activity levels over time (Alahmari et al, 2014). It has been documented that reduced levels of physical activity are a predictor of 30-day hospital readmissions post discharge for an acute exacerbation (Chawla et al, 2014) while a larger number of daily steps measured by accelerometry were associated with a reduced risk of hospitalisation for COPD and a longer time to death (Durheim et al, 2015; Garcia-Rio et al, 2012). Higher levels of physical activity are associated with a lower risk of mortality in both people with (Waschki et al, 2011) and without COPD, meaning that starting an activity intervention early on in the course of COPD will result in a decreased risk of death (Vaes et al, 2014). COPD patients with hypoxemia have a larger number of hospitalizations to go along with a significantly lower level of daily physical activity as compared to non-hypoxemic COPD controls (Saglam et al, 2015). Contrary to what most studies report, Schonmann and colleagues (2015) found that daily physical activity and steps per day were not related to number of acute exacerbations of COPD.

1.2.2 Physical Activity and COPD and Mental Health

Activity levels have previously been found to be related to mental health measures as well. Self-efficacy specific to the task of walking is correlated with daily physical activity levels with higher levels of self-efficacy being related to increased physical activity (Belza et al, 2001;

Booth et al, 2000; Steele et al, 2000; Hartman et al, 2013). Fear of becoming short of breath has been found to be a barrier to physical activity, along with worrying about needing to use an inhaler and fear of oxygen desaturation (Danilack et al, 2014). Those who worry more have fewer steps per day as measured by accelerometry (Danilack et al, 2014). Higher number of daily steps (Durr et al, 2014; Moy et al, 2009) as well as more time spent in various intensity levels of physical activity (Esteban et al, 2010; Miravitlles et al, 2014; Kim & Kim, 2014) are related to higher levels of health related quality of life. In general, there is both a lower physical and mental quality of life associated with decreased levels of physical activity (Garcia-Aymerich et al, 2004). Further identified as impacting physical activity are a lack of interest, feeling as if they are too ill or disabled, being too busy, having difficulties committing to an exercise program, and having decreased social support (Benzo et al, 2015).

Anxiety and depression are another mental health measure that has been associated with physical activity levels. The presence of depression in those with COPD is related to a decreased mean daily walking time (Miravitlles et al, 2014), a reduced number of steps taken per day (Di Marco et al, 2014), and a reduced overall level of physical activity (Duenas-Espin et al, 2016). Improvements in depression were seen after a multimodal exercise program performed in hospital (Torres-Sanchez et al, 2016). The presence of anxiety and depression may also moderate the impact of self-management education on physical activity levels with those having more anxiety and depression showing less physical activity with increased self-management knowledge (Schuz et al, 2015). There is one study that, counter to all other studies, found that that there are higher levels of physical activity in those with anxiety with the theory that this relationship may exist because anxious people may be more restless and have increased activity as a coping mechanism (Nguyen et al, 2013).

1.2.3 Other Factors in Physical Activity and COPD

There are external factors to be considered when inspecting relationships contributing to physical activity levels. Individuals with COPD identify a lack of infrastructure to support a more physically active lifestyle as being a large barrier (Amorim et al, 2014). Other barriers identified by individuals with COPD include the weather, transportation to a place where they can be active, and financial limitations for joining a group exercise program (Thorpe et al, 2014). There are a number of enablers to increasing physical activity levels including having adequate social support, a routine that works well with physical activity, more active extracurricular activities, access to health care professionals for assistance, establishing personal goals to work towards, and being motivated by feeling better with physical activity (Thorpe et al, 2014).

1.2.4 Measuring Physical Activity

There are multiple methods used to measure physical activity in the COPD population, including questionnaires, activity diaries, pedometers, accelerometers, and assessment of energy expenditure through doubly labeled water or calorimetry (Benzo, 2009). The use of accelerometers has become the latest standard in activity tracking likely because the technology has advanced and become much more accessible and user friendly in recent years. This leads to increased use of accelerometry where it was once only accessible to those studies that were well-funded. It has been found that the use of a pedometer underestimates energy expenditure where an accelerometer is more accurate when compared to indirect calorimetry in a COPD population (Cavalheri et al, 2011). A similar study found that a pedometer underestimates activity time during activities of daily living but is accurate when estimating energy expenditure (Sant'Anna et al, 2012). Another study (Furlanetto et al, 2010) found the opposite, stating that the pedometer is accurate for both step counting and energy expenditure estimation (except at slower speeds) whereas the accelerometer was not accurate at step counting but it was good with energy expenditure. Yet another study found that an accelerometer is accurate at estimating energy expenditure compared to an exhaled breath metabolic system when looking at COPD subjects walking at a slow to moderate pace (Patel et al, 2007). When using accelerometry, it has been shown that the minimal important difference in steps to be considered an improvement in physical activity is between 600-1100 steps per day (Demeyer et al, 2016). An improvement of at least 600 steps per day is related to a decreased risk of hospital admission for an acute exacerbation of COPD (Demeyer et al, 2016). The comparison of accelerometer reported physical activity and patient self-reported physical activity levels tend to disagree with patients overestimating their physical activity levels and underestimating their time spent sitting while the accelerometer agrees with video recordings of activity (Pitta et al, 2005). Another study by Steele and colleagues (2000) found similar results with accelerometry report not agreeing with patient self-reported physical activity levels. It seems that no method of easily recording physical activity levels is 100% accurate but accelerometry seems to give a fairly accurate estimate, especially when comparing results using the same type of accelerometer.

With the use of accelerometry, there has been much learned about physical activity levels and patterns in the COPD population. All levels of severity of COPD actually achieve bouts of moderate to vigorous activity, although these bouts become less frequent and shorter as severity increases (Donaire-Gonzalez et al, 2013). Sixty-one percent of individuals with COPD achieve the recommended 30 minutes of moderate to vigorous physical activity at least 5 days per week (Donaire-Gonzalez et al, 2013) but another study places this number substantially lower at 27% of those with mild COPD, 10% of those with moderate, and 17% of those with severe COPD achieving these recommended levels (Eliason et al, 2011). Every increase of 1000 steps per day as measured by an accelerometer results in a decreased risk of hospitalisation for acute exacerbation and an increased time to death (Durheim et al, 2015).

1.2.5 Physical Activity Interventions in COPD

There are several interventions that have been found to be effective in increasing physical activity levels in those with COPD. These interventions can include assisting this population with individualized goal setting (Cavalheri et al, 2016) to help ensure that the exercise goals to be met are something that is specific and relevant to the person needing to engage in higher levels of activity. The inclusion of a physical activity focused behavioural intervention during a pulmonary rehab program has shown to be more effective than pulmonary rehab alone (Cruz et al, 2016). The use of motivational interviewing to invite a lifestyle change to include increased activity levels has also been shown to be effective (Cavalheri et al, 2016). Having frequent opportunities to interact with and contact health-care providers can also assist in improving physical activity in those with COPD (Cavalheri et al, 2016). It has also been identified that a lack of intrinsic will-power can be problematic when attempting to initiate physical activity (Amorim et al, 2014). Simply having the addition of a pedometer can help to increase daily physical activity levels as well as quality of life in those with COPD compared to those who received encouragement to be more active alone (Mendoza et al, 2015).

1.2.6 Pulmonary Rehabilitation

One of the biggest interventions studied with respect to increasing physical activity levels in individuals with COPD is pulmonary rehabilitation. The Canadian Thoracic Society recommends that individuals with COPD attend a pulmonary rehab program, particularly following an exacerbation, if the severity of COPD is moderate to very severe, and also recommend that the program last longer than 8 weeks and include resistance training along with aerobic training (Marciniuk et al, 2010). Overall, the results of pulmonary rehab programs are mixed with some reporting a positive impact on physical activity and others reporting no change in physical activity levels. Further investigation is required in order to fully explore the relationship between pulmonary rehab and physical activity.

There are a number of studies reporting that pulmonary rehab does improve physical activity levels. One study found that one year of home based pulmonary rehab was sufficient to improve daily physical activity levels, especially with the addition of a pedometer (Kawagoshi et al, 2015). A 4-week internet based program does improve daily step count but this result does not last beyond the intervention time as the step counts have declined back to baseline at a one-year follow-up (Moy et al, 2016). Increases in walking time occur with pulmonary rehab but these increases in daily walking time did not occur until after 6 months of participation in the rehab program and were also associated with a decrease in shortness of breath (Pitta et al, 2008). The addition of counselling sessions can improve daily physical activity levels after 3 months in pulmonary rehab but these effects only lasted until a 15 month follow up in those who were considered sedentary at baseline (Altenburg et al, 2015). There is evidence that when there are increases in physical activity levels associated with pulmonary rehab, they are associated with use of an activity monitor and they only last a limited time before declining back to baseline levels again (Cruz et al, 2014).

On the contrary, it has also been found that pulmonary rehab does not improve physical activity levels but does increase exercise capacity (Miyamoto et al, 2014; Mador et al, 2011; de Albuquerque et al, 2016; Pitta et al, 2008) and quality of life (Mador et al, 2011), meaning that it may help improve an individual’s function with COPD but may not change their behaviour with respect to physical activity after the intervention. Being in a pulmonary rehab program for 3 months is not sufficient to make a change in daily physical activity levels despite improvement in strength (Pitta et al, 2008). Measurement of steps per day, total minutes of activity per day and METS per day all have been shown to have no change after participating in a pulmonary rehab program (Demeyer et al, 2014). The addition of individual counselling sessions regarding activity also does not help the pulmonary rehab intervention improve daily physical activity levels in COPD (Burtin et al, 2015). Even with a maintenance program of follow up sessions after participation in a pulmonary rehab program, there was not improvement in physical activity levels (Wilson et al, 2015). Yet another study found that there are two groups who tend to attend pulmonary rehab – those who are fairly active prior to attending and those who are not – both of these groups did not change their level of daily physical activity after participation in a pulmonary rehab program (Saunders et al, 2015).

1.3 COPD, Anxiety, and Depression

Anxiety is defined as "apprehension of danger and dread accompanied by restlessness, tension, tachycardia, and dyspnea, unattached to a clearly identifiable stimulus" (Stedman, 2005, page 97) and can present as generalized anxiety disorder, panic disorder, posttraumatic stress disorder, or phobia (Stedman, 2005). Depression is defined as "a temporary mental state or chronic mental disorder characterized by feelings of sadness, loneliness, despair, low self-esteem, and self-reproach" (Stedman, 2005, page 396) and can be accompanied by "psychomotor retardation or less frequently agitation, withdrawal from social contact, and vegetative states" (Stedman, 2005, page 396). The Diagnostic and Statistical Manual has a list of criteria to meet for both generalized anxiety disorder and depression but the majority of studies reviewed use a questionnaire based diagnosis instead of a psychiatrist diagnosis for these mental health diagnoses.

1.3.1 Prevalence of Anxiety and Depression in COPD

It has been estimated that 12.7% of people with COPD have anxiety as a comorbidity while 26.3% have depression (Ajmera et al, 2015) and that these are among the comorbidities identified to be associated with poor COPD medication management (Ajmera et al, 2015). Another study found these numbers to be reversed with COPD patients reporting anxiety in 31% of their population and depression in 13% (Bentsen et al, 2014). In a pulmonary rehab group it was found that 33% of the study participants had depressive symptoms and 42% had increased levels of anxiety (Bratek et al, 2015). In yet another study, the prevalence of anxiety and depression was similar with 13% of the COPD participants experiencing depression and 11.8% experiencing anxiety (Frei et al, 2014). Twenty-one percent of people with COPD have been found to have both anxiety and depression (Bhattacharya et al, 2014) or 7.3% have a mixed anxiety-depression diagnosis (Gonzalez-Gutierrez et al, 2016). Approximately 76% of individuals with COPD who have psychiatric comorbidities are unaware of these comorbid conditions (Gonzalez-Gutierrez et al, 2016). Use of DSM-IV criteria give a major depressive disorder prevalence of 8.7% in those with COPD and generalized anxiety disorder a prevalence of 6.4% (Rapsey et al, 2015). Suffice to say, both anxiety and depression have the potential to be problematic in a COPD population.

Symptoms of depression appear to be more prevalent in women than in men (Raherison et al, 2014; de Carvalho Lopes Orlandi et al, 2016; Schane et al, 2008; Lou et al, 2012) with 41.6% of women with COPD experiencing symptoms of depression and 6.6% of men (de Carvalho Lopes Orlandi et al, 2016). Women appear to have both more frequent anxiety and depression associated with their COPD than men (Naberan et al, 2012). Another study found much higher numbers for males with 71% of men with COPD have symptoms of depression (De, 2011). In yet another study group it was found that 60% of those with COPD experienced symptoms of depression and that 59% of these individuals were female (Fleehart et al, 2014). When both anxiety and depression are studied in a COPD population, it was found that 25.2% of men have anxiety compared to 38.3% of women and 12.9% of men have depression while 38.3% of women (Di Marco et al, 2006). Women tend to have more persistent depression than men as well (Yohannes et al, 2016). Both anxiety and depression are associated with being younger in those with COPD (Lou et al, 2012).

Use of the Hospital Anxiety and Depression Scale (HADS) shows a variety of scores for anxiety and depression in individuals with COPD (Phan et al, 2016; Al-Gamal, 2015; Duenas-Espin et al, 2016). Scores for the HADS subscales for anxiety and depression are broken down into the categories of none (0-7), mild (8-10), moderate (11-14), and severe (15-21). Bentsen and colleagues (2013) found that individuals with COPD had an average HADS anxiety score of 5.78 and depression score of 4.55 with a range of 0-15 and 0-19 respectively while Allam and colleagues (2017) found a mean anxiety score of 8.94 ± 3.37 and a mean depression score of 7.12 ± 3.12. Another study (Harrison et al, 2011) found a mean anxiety score of 7.99 ± 4.10 and a mean depression score of 6.80 ± 3.56. Previous findings have indicated that approximately 29% of those with COPD have a HADS depression score of ≥ 8 and approximately 32% have a HADS anxiety score of ≥ 8, indicating a clinically significant level of depression and anxiety respectively (Phan et al, 2016). Al-Gamal (2015) found that 64% scored above 8 for anxiety and 68% scored above 8 for depression with mean scores of 9.31 ± 4.39 and 9.41 ± 4.48 respectively. It is unknown why there is such a large discrepancy between these results. The study by Al-Gamal (2015) did not report on severity level of COPD but the difference may be due to a higher level of severity of obstruction. The populations studied in these two papers were also from two different societies with Al-Gamal (2015) studying people from the middle east and Phan (2016) studying individuals from Australia. It has previously been found that there are variations in both anxiety (Marques et al, 2011) and depression (Dere et al, 2015) between various races and cultures. With a cut-off score of ≥11 for both anxiety and depression, it has been found that 23% have anxiety and 12% have depression (Duenas-Espin et al, 2016).

1.3.2 Dyspnea, Anxiety, Depression, and COPD

One of the predominant symptoms of COPD that has been investigated for how it interacts with anxiety and depression is breathlessness. Since part of having anxiety and part of having COPD include breathlessness, it is no wonder that the two diagnoses are related. It can be imagined that the symptom of dyspnea may also make a person exhibit symptoms of depression as well. It has been found that there is a correlation between dyspnea levels and both anxiety and depression (Al-Gamal & Yorke, 2014; Borges-Santos et al, 2015; von Leupoldt et al, 2011; Doyle et al, 2013; An et al, 2010) and these higher levels of anxiety and depression extend to the spouse of the person with COPD as well (Al-Gamal & Yorke, 2014). This finding underscores the importance of providing support to both patients as well as their spouses. Anxiety alone has also been correlated with dyspnea at rest (Giardino et al, 2010) and exertional dyspnea and when used in a regression, anxiety was predicted mostly by shortness of breath on exertion after adjusting for sex, age, baseline dyspnea, and exercise capacity (de Voogdt et al, 2010). Depression alone has also been associated with dyspnea in COPD (Schane et al, 2008). New onset of depression is also related to having moderate to severe dyspnea (Yohannes et al, 2016). There are a variety of descriptors that are used for dyspnea in a respiratory population but it was found that more negative descriptors such as "frightening" and "awful" are more frequently used to describe dyspnea in those with higher levels of anxiety (Chang et al, 2015). The use of respiratory muscle training to improve dyspnea levels has been shown to also improve symptoms of anxiety (El-Gendry, 2015). Sex differences in perceived dyspnea have also been found in the COPD population where significantly more female patients experience higher levels of dyspnea than males for the same given ventilatory impairment (Di Marco et al, 2006).

1.3.3 Neural Basis for Anxiety and Depression in COPD

The brain's structure and function may influence the experience of anxiety and depression in COPD. Both anxiety and dyspnea are found to stimulate the limbic system, which may be why anxiety and COPD are often found to coexist and may also be why anxiety is maintained in those with COPD (Amiri et al, 2012). A subsequent study has found that the areas of the brain responsible for processing dyspnea and fear have a decrease in the amount of gray matter, especially in those with more severe COPD (Esser et al, 2015). The reduction in anterior cingulate cortex gray matter was related to an increased fear of breathlessness (Esser et al, 2015).

1.3.4 Pulmonary Rehabilitation/Health Care Support, Anxiety, and Depression in COPD

Pulmonary rehabilitation and physical activity have the potential to impact anxiety and depression and vice versa. It has been found that pulmonary rehab has been effective in improving symptoms of both anxiety and depression (da Costa et al, 2014; Catalfo et al, 2016; Coventry, 2009; Trappenburg et al, 2005; Bodescu et al, 2015), regardless of the severity level of COPD (Tselebis et al, 2013). Home based rehab is also effective in improving anxiety and depression (Grosbois et al, 2015). Pulmonary rehab may help in improving symptoms of anxiety due to its ability to improve shortness of breath (Amiri et al, 2012) and may help improve symptoms of depression due to a social support network that is formed through the participation in the program. Another study found that there was no improvement in anxiety with participation in pulmonary rehab but there was a decrease in the level of depression (Bratas et al, 2010; Pirraglia et al, 2011). Anxiety during pulmonary rehab is improved by the use of ambient music in addition to the usual rehab interventions (Reychler et al, 2015). Having higher levels of anxiety and depression in pulmonary rehab is related to increased adverse events during rehab sessions with these adverse events being any reason to stop a 6-minute walk test as outlined by the American Thoracic Society guidelines (Roberts et al, 2015). Having symptoms of depression puts one at risk of dropping out of a pulmonary rehab program (Heerema-Poelman et al, 2013). Related to pulmonary rehab, there are also studies that examine the relationship between exercise capacity and anxiety and depression. One such study found that anxiety is related to a decreased functional capacity in a 6-minute walk test and a decreased peak workload in a maximal ergometry test (Giardino et al, 2010). Symptoms of depression but not symptoms of anxiety were found to reduce physical activity levels in cohort of COPD patients (Duenas-Espin et al, 2016).

A simple support system of entering data into an electronic nurse monitoring station from home has the effect of reducing both anxiety and depression in those with COPD (Kenealy et al, 2015), potentially due to the knowledge that someone is monitoring them and can intervene in case of emergency. Having a health management program to enhance COPD education also helps to decrease anxiety levels and symptoms of depression (Lou et al, 2015). It has been found that COPD patients who have anxiety or depression were less likely to have more COPD knowledge (Zhang et al, 2014) leading to the idea that these symptoms may potentially reflect a fear of the unknown.

There are several potential mechanisms that allow physical activity to impact anxiety. A previous review of the literature in 2013 by Anderson and Shivakumar and one completed by Strohle in 2009 found that there are physiological mechanisms, neurotrophic factors, and psychological mechanisms for physical activity to reduce symptoms of anxiety. The physiological mechanisms include exercise induced changes in the hypothalamic-pituitary-adrenal axis (modulating reactions to stress and anxiety), changes in the monoamine system (including increases in norepeinephrine and serotonin levels with exercise), and changes in the opioid system (release of endorphins) (Anderson & Shivakumar, 2013). Neurotrophic factors are shown to be reduced in those with increased anxiety and depression but have subsequently increased with the introduction of physical activity, along with an increased neural growth (Anderson & Shivakumar, 2013). There are several psychological mechanisms for physical activity to reduce anxiety. These include changes in anxiety sensitivity when encountering unpleasant sensations in physical activity along with increases in self-efficacy and a use of distraction techniques (Anderson & Shivakumar, 2013; Strohle, 2009).

1.3.5 Severity of COPD/Disease Prognosis and Anxiety and Depression

There has also been found to be a relationship between both anxiety and depression and stage of COPD with level of anxiety and depression increasing as severity of COPD increases (Balcells et al, 2010; Bratek et al, 2015) and more individuals with COPD suffering from anxiety and/or depression as their COPD worsens (Mehta et al, 2014). Depression alone is also associated with stage of COPD with worsening depression being related to more severe COPD (De, 2011; Omachi et al, 2009). The majority of patients with severe COPD experience anxiety related to death and anxiety related to living their life (Strang et al, 2014).

One would expect there to be a relationship between anxiety, depression, and COPD prognosis as adding comorbidities tends to lead to a poorer disease prognosis. Indeed, this is the case as it has been found that both depression and anxiety lead to a more adverse prognosis in COPD with an increased risk of having an acute exacerbation and an increased risk of death (Atlantis et al, 2013). Having anxiety alone can also increase the risk of hospital readmission due to an acute exacerbation of COPD (Tsui et al, 2016). Having depression comorbid with COPD increases mortality risk by 3.8 times when interacting with smoking status while having anxiety and smoking increases mortality risk by 4.3 times with more years of smoking increasing that risk in both cases (Lou et al, 2014). In a study monitoring depression, anxiety, and mortality in a COPD population, it was found that after 4 years, 28.5% of those with anxiety had died and 30.9% of those with depression had passed away as compared to the cumulative mortality of 20% (Lou et al, 2014). This means that those with COPD who have anxiety or depression are at increased risk of dying (Lou et al, 2014). Both anxiety and depression were both found to be related to an increased mortality as well as increased healthcare use (Yohannes et al, 2010). Mortality has been significantly related to anxiety level in COPD but this relationship disappears after controlling for body mass index and disease severity (Einvik et al, 2015).

Not only is mortality increased with COPD but also hospital admission rate. Risk of readmission to hospital for an acute exacerbation of COPD is related to increased frequency of depression for both one-year readmission risk and 30-day readmission risk (Iyer et al, 2015) and 30-day readmission risk for those with both depression and anxiety. The presence of depressive symptoms leads a patient with COPD to be 2.8 times more likely to have an acute exacerbation of COPD as well as they also have their first exacerbation earlier than those without depression (148 days compared to 266 days) (Jennings et al, 2009). Both new onset and persistent depression is related to increased numbers of exacerbations (Yohannes et al, 2016). Having symptoms of anxiety and/or depression can impact the level of clinical control one has over their COPD with higher levels of anxiety and/or depression leading to poorer clinical control (Borges-Santos et al, 2015). Another study has found that higher levels of anxiety in COPD are related not only to an increased risk of acute exacerbations but also increased functional impairments and a decreased submaximal exercise capacity (Eisner et al, 2010). Increased levels of depression are related to a lower treatment adherence in COPD while anxiety level has no bearing on adherence (Turan et al, 2014). Higher levels of both depression and anxiety are related to an increased frequency of symptoms associated with COPD as well as increased symptoms of fatigue (Doyle et al, 2013).

1.3.6 Quality of Life, Anxiety, and Depression in COPD

Quality of life seems to be intuitively linked to anxiety and depression. Al-Gamal (2014) found that these high levels of anxiety and depression are related to a lower than normal quality of life in both the patient with COPD and their spouse with the spouse exhibiting a slightly higher quality of life than their partner. Other studies have found similar relationships with higher levels of anxiety and depression being related to a decreased health related quality of life (HRQoL) (An et al, 2010; Balcells et al, 2010; Giardino et al, 2010; Mehta et al, 2014; von Leupoldt et al, 2011; Yohannes et al, 2010; Lou et al, 2012). Yet others have found that depression alone is related to quality of life (Kwon & Kim, 2016; Iguchi et al, 2013; Maric et al, 2016; Xiang et al, 2015; Omachi et al, 2009) with quality of life being associated to activity and disease impacts specifically being related to depression (Iguchi et al, 2013). There is a stronger association between anxiety and HRQoL in those individuals with COPD who are currently working as compared to those who are retired (Balcells et al, 2010). The type of quality of life analyzed may show different relationships with anxiety and depression with a worse disease specific quality of life being connected more to anxiety and worse general quality of life being related more to a higher level of depression (Bentsen et al, 2014).

1.4 COPD and Quality of Life

Quality of life is defined as "a patient's general well-being, including mental status, stress level, sexual function, and self-perceived health status" (Stedman, 2005, page 1233). When compared to healthy controls, individuals with mild COPD have a lower physical quality of life but not mental quality of life (Wacker et al, 2014). In general, those with COPD have poorer quality of life as compared to healthy controls (Brown et al, 2010).

1.4.1 Quality of Life and COPD Severity, Stability, and Gender

Poor HRQoL has been predicted by level of severity of COPD (Ekici et al, 2015; Kwon & Kim, 2016; Wu et al, 2015; Kim et al, 2014; Lin et al, 2014), amount of shortness of breath present (Kim et al, 2014; Ekici et al, 2015), and level of anxiety (Ekici et al, 2015). The quality of life tends to worsen as COPD progresses (Dignani et al, 2016; Negi et al, 2014; Azargoon et al, 2016) with those who have had their COPD longer having worse QOL (Maric et al, 2016). There has been shown to be significant variation of HRQoL within each level of severity of COPD but all severity categories experience a significant impairment in HRQoL (Jones et al, 2011). Those with mild COPD also experience significantly decreased HRQoL compared to normal values (Negi et al, 2014). More severe symptoms, regardless of disease severity, are also related to poorer HRQoL (Mehta et al, 2014). Having any respiratory symptoms in adults, even without a diagnosis of COPD or asthma, will also lead to a decrease in quality of life (Voll-Aanerud et al, 2010). Levels of HRQoL may have a tendency to fluctuate over time in patients with stable COPD and the disease specific QOL changes are associated with levels of both anxiety and depression (Borge et al, 2016).

Quality of life also has the potential to be linked to disease stability. Stable COPD patients have higher HRQoL levels compared to those experiencing an acute exacerbation (Irwin et al, 2015) while needing to be hospitalized with a stay in intensive care means lower HRQoL compared to COPD patients not needing to be hospitalized (Berkius et al, 2013). Two years after their ICU stay, these individual's QOL was no different than the control group (Berkius et al, 2013). HRQoL is poorer in individuals with COPD and lower QOL is related to increased number of exacerbations, especially those requiring hospitalization (Filipowski et al, 2014). Poorer levels of health related quality of life are linked to increased numbers of hospitalizations (Xiang et al, 2015). It is also linked to increased medical costs for COPD patients (Wu et al, 2015). Participants in a study by Berkius and colleagues (2013) who passed away during the study had poorer HRQoL compared to those who lived through the entirety of the study.

There also appears to be sex and age differences in quality of life in a COPD population. Women tend to have poorer quality of life associated with their COPD than men (Naberan et al, 2012; Raherison et al, 2014; Kanervisto et al, 2010) and that this worse QOL is related to activities of daily living and exercise (Kanervisto et al, 2010). Counter to these findings, another study found that females with COPD had better HRQoL than their male counterparts (Kim & Kim, 2014). Age has been shown to have an impact on HRQoL with increased age being related to a worse quality of life (Holm et al, 2014), however Kim & Kim (2014) found that the relationship between age and HRQoL was only valid in women, not men.

1.4.2 Quality of Life and Pulmonary Rehabilitation in COPD

Pulmonary rehab has been found to improve HRQoL in patients with COPD (Bratas et al, 2010; Trappenburg et al, 2005; Gottlieb et al, 2011; Mkacher et al, 2016; Ninot et al, 2011; Bodescu et al, 2015). However, the improvement in QOL may be fleeting as it has been found that this relationship disappeared 18 months after a 7-week intervention (Gottlieb et al, 2011). The addition of balance training to pulmonary rehab further increases QOL beyond what just pulmonary rehab is able to do (Mkacher et al, 2016). Other physical activity-focused interventions have also shown an improvement in HRQoL (Cruz et al, 2016). An internet based physical activity intervention helped to increase HRQoL but the results were not maintained past the end of the intervention (Moy et al, 2016). Conversely, it has also been found that while there were slight improvements in HRQoL with a pulmonary rehab intervention, these were not actually meaningful changes (Roman et al, 2013).

Education is also an integral part of pulmonary rehab. Education on self-management alone can also improve HRQoL in individuals with stable COPD (Labreque et al, 2011; Oancea et al, 2015) but it is better in combination with a supervised exercise program (Ninot et al, 2011). Higher levels of self-management abilities in COPD are shown to improve quality of life but this relationship is mediated by the ability to employ positivity in everyday situations (Benzo et al, 2016). Self-management education alone is not as effective at improving HRQoL as more specific coping skills training in a COPD population (Blumenthal et al, 2014). Having a pharmacy-based education program focusing on smoking-cessation, preventing acute exacerbations, and having the correct medications prescribed also helped to improve HRQoL (Wright et al, 2015).

1.4.3 Quality of life and Symptoms of COPD

Poorer HRQoL is related to increased dyspnea related fear but there are those with higher dyspnea related fear that have a larger improvement in HRQoL with participation in a pulmonary rehab program (Janssens et al, 2011). Quality of life in pulmonary rehab participants with COPD can be predicted by level of dyspnea at rest (Jacobsen et al, 2012). When employing guided deep breathing as an intervention, it has been found that this improves symptom specific QOL (Borge et al, 2015), perhaps due to an improvement in dyspnea.

Health related quality of life may be related to a number of other symptoms and comorbidities in the COPD population. Pain in individuals with COPD can impact QOL with increased levels of pain affecting both disease specific QOL and global QOL (Borge et al, 2011). Individuals with COPD who suffer from sleep disorders also tend to experience worse QOL (Dignani et al, 2016). A decreased level of cognition is also significantly related to poorer HRQoL (Park & Larson, 2015). Smoking cessation is not only important for the health of COPD patients but also will help to improve their quality of life (Papadopoulos et al, 2011). Having poorer HRQoL is also related to higher rates of disability in both men and women with COPD (Rodriguez-Rodriguez et al, 2013). A higher number of general comorbidities contributes to a worse HRQoL (Xiang et al, 2015; Jones et al, 2011).

1.4.4 Quality of life and Self-efficacy in COPD

Health related quality of life is related to self-efficacy and level of optimism in those with COPD with poorer HRQoL linking to low self-efficacy and decreased optimism (Benzo et al, 2016; Popa-Velea & Purcarea, 2014), regardless of level of disease severity (Popa-Velea & Purcarea, 2014). Higher levels of self-efficacy are related to higher levels of quality of life as well as increased functional capacity (Jackon et al, 2014). In contrast, another study found that higher physical quality of life was related to a lower self-efficacy but this relationship was borderline significant (Bonsaksen et al, 2014).

1.5 COPD and Illness Perceptions

Illness perceptions are a product of the common-sense model of illness representations. This self-regulatory model has several components to illness representations – identity, causality, timeline, and consequences (Baumann et al, 1989). All individuals with an illness have beliefs associated with these components and there is beginning to be a knowledge base showing trends in how people cope with their illness based on how they cognitively perceive that illness. When an individual initially faces a threat to their health, they tend to believe that their condition will be acute (limited duration) and can be treated/cured (Leventhal et al, 1984). As they progress through their illness, their perceptions of their condition will be shaped and eventually reshaped according to whether they have had success or failure with various coping mechanisms and management techniques (Leventhal et al, 2003). These perceptions are integrated with a person's pre-existing illness schemata to influence coping style and illness management (Hale et al, 2007). Because these beliefs are fluid and change based on experience, coping mechanisms and disease management can be modified when illness perceptions change. Altering one's illness beliefs may either improve or worsen how well someone manages their illness. There are five core dimensions to illness perceptions: identity, cause, timeline, consequences, and cure-control.

1.5.1 Illness Perceptions and Level of Disability in COPD

The level of disability being experienced by individuals with COPD can be impacted by their illness representations. A study by Braido and colleagues (2011a) highlighted the importance of disability in relation to illness perceptions. It was found that level of disability had an impact on illness representations with disabled patients having more awareness of the chronicity of their COPD, regarded their lung health as having worse consequences (Braido et al, 2011a; Scharloo et al, 1998), and listed more symptoms that they associated with their disease

(Braido et al, 2011a; Scharloo et al, 2000; Mewes et al, 2016). Lower levels of disability are related to more positive illness perceptions along with a strong internal locus of control and higher levels of mental health (Mewes et al, 2016). In addition to this, a stronger illness identity has a greater association with decreased disease specific functioning (Scharloo et al, 1998) as well as role and social functioning (Scharloo et al, 1998; Scharloo et al, 2000). In a subsequent study by Braido and colleagues (2015) it was found that all of the various dimensions of illness perceptions (with the exception of the timeline dimension) were significantly different when comparing those who were considered to be disabled with those who were not. It was also determined that those participants with less disability/more self-sufficiency perceived that they have more control over their COPD and increased confidence in their treatments (Braido et al, 2011a). A belief that the disease is less chronic and that it will/can improve was also associated with better physical function (Scharloo et al, 2007). Perception of symptoms explains the most overall variance in function in COPD, more than coping strategies and medical variables (Scharloo et al, 1998). Part of the reason for some of these differences between those who cope well with their COPD and those who do not has been hypothesized to be related to level of education with those with a higher level of disability having a lower level of education (Braido et al, 2015), meaning they may not have the same knowledge regarding their disease and the importance of typical management strategies.

There tends to be a relationship between the somatic symptoms experienced by those with COPD and an individual's illness representations. A study by Hyphantis and colleagues (2014) found that higher levels of somatic symptoms were related to the level of personal control they felt they had over their disease as well as how effective they thought their treatments were in controlling their COPD. A higher number of symptoms they perceived to be attributable to their disease was related to the number of actual symptoms they experienced (Hyphantis et al, 2014).

1.5.2 Illness Perceptions and Self-management in COPD

Self-management is an important part of successful chronic disease management. It is also an essential component of most pulmonary rehabilitation programs. When Dowson and colleagues (2004) delved into the subject of self-management and its relationship with illness beliefs in people with COPD with an acute exacerbation, it was found that the patients who had higher perceived control over their COPD had better scores on the COPD self-management interview. There tended to be lower scores on self-management strategies and disease knowledge in patients with symptoms of depression (Dowson et al, 2004). It was also found that patients who had panic tendencies had the ability to make it appear that they have the knowledge required for self-management but they may not be able to use this knowledge effectively when in distress (Dowson et al, 2004). Over half of the sample tested believed that they had sufficient knowledge to self-manage their COPD but this was not reflected in their self-management knowledge scores (Dowson et al, 2004). Those who believed that their health care behaviour does little to influence their condition, had decreased motivation to self-manage their disease (Dowson et al, 2004). It was found that a written action plan improved patient confidence in self-management, especially in those prone to panic attacks (Dowson et al, 2004). Two subsequent studies (Bos-Touwen et al, 2015; Korpershoek et al, 2016) did not take such an in depth approach to analyzing the relationship between self-management and illness perceptions but did find that those who had poor activation of self-management strategies also had more negative illness perceptions.

As part of disease self-management, knowing when to go to the emergency room is an important skill. It has been found that negative perceptions regarding disease prognosis were a predictor of emergency room return visits in male veterans with COPD (Stehr et al, 1991). Having more negative illness perceptions was related to an increased risk of emergency room return visits and that number of acute exacerbations of COPD were related to all dimensions of illness perceptions (Stehr et al, 1991). Ninou and colleagues (2016) also studied the interaction between illness perceptions and use of urgent health care. They found that the illness comprehension dimension of illness perceptions was associated with a larger number of emergency department visits, along with a younger age, a higher number of comorbidities, and increased symptom burden. Examining an individual with COPD's illness representations can help to predict future health care utilization by their association with visits to an outpatient clinic (Scharloo et al, 2000). It has been determined that people who attribute their COPD to stress and other emotional causes are more likely to have a larger number of outpatient clinic visits and that emotional causes explained 8% of the variance in clinic visits (Scharloo et al, 2000).

1.5.3 Illness Perceptions and Pulmonary Rehabilitation in COPD

Management of your disease involves more than just emergency department visits. Pulmonary rehab and physical activity are also important. Fischer and colleagues (2010) examined whether or not there was a change in illness perceptions in patients with COPD after pulmonary rehabilitation. In this sample, the length of time since diagnosis was associated with a larger number of perceived consequences and more of a chronic timeline (Fischer et al, 2010). An increased 6-minute walk distance was related to a decrease in perceived consequences of COPD and decreased emotional representations (Fischer et al, 2010). This same study determined that if a participant felt that they achieved their objectives in pulmonary rehab, they tended to perceive the consequences of their disease as less serious, gained confidence in their ability to control their symptoms and thought of their COPD as being more cyclical (Fischer et al, 2010). Having an increased sitting time was related to more confidence in their treatment control (Hartman et al, 2013) but there has not been a relationship found between illness representations and amount of physical activity an individual with COPD participates in (Weldam et al, 2013). Having said that, they do help to predict exercise capacity after participating in a pulmonary rehab program (Zoeckler et al, 2014). More specifically, a more chronic perceived timeline and decreased illness coherence was related to a lower 6-minute walk distance (Zoeckler et al, 2014).

1.5.4 Illness Perceptions and Quality of Life and COPD

Quality of life is an important aspect of chronic disease management. It has been found that 40% of patients with COPD have impaired well-being with perceived worse general health (Braido et al, 2011b). Having COPD lends itself to also having poorer general illness perceptions than those with asthma or those with a common cold and, in general, more negative illness representations were related to a poorer quality of life (Tiemensma et al, 2016; Vaske et al, 2016). All aspects of illness perceptions have the ability to lead to poorer quality of life – perception of more consequences, a more chronic timeline, decreased personal and treatment control, a stronger COPD identity, more concern about their disease, decreased illness coherence, and an increased emotional response (Tiemensma et al, 2016). Other studies have found that individuals with better HRQoL considered their disease and its consequences to be less serious (Braido et al, 2011b) and were more confident in their treatment (Braido et al, 2011b; Weldam et al, 2014). Their perceived timeline of the disease was less cyclical and chronic and they reported better mental and physical health status (Braido et al, 2011b). They also understood their COPD better, had less of a daily impact from their disease, and less emotional representations (Weldam et al, 2014). Other studies have found that higher physical HRQoL was related to less perceived consequences (Bonsaksen et al, 2014; Borge et al., 2014; Weldam et al, 2014), symptoms

(Bonsaksen et al, 2014), concerns (Borge et al, 2014), higher treatment control (Weldam et al, 2014), and a lower illness identity (Borge et al, 2014) in those with COPD. Impairments in mental HRQoL are related to higher scores in consequences, identity (Borge et al, 2014), perceiving more treatment control (Weldam et al, 2014), and more emotional representation (Bonsaksen et al, 2014; Borge et al, 2014; Weldam et al, 2014). When taking a more general look at the impact of illness representations on HRQoL, it has been found that more positive illness perceptions are associated with improved HRQoL, along with lower symptoms of depression (Weldam et al., 2013). A belief that COPD is not going to improve is strongly related to a diminished quality of life (Scharloo et al, 2007). As the scores increase on dimensions of emotional representations and psychological attributions (Scharloo et al, 2000; Scharloo et al, 2007; Hoth et al, 2011), identity, and consequences, quality of life scores decrease (Scharloo et al, 2007). This means that those who have a stronger disease identity, perceive consequences as being more severe, and having increased emotional reactions to and psychological attributions of their disease have lower quality of life. While Braido and colleagues (2011b) showed that higher confidence in treatment was associated with improved well-being, a perceived lack of personal control over the disease was not associated with quality of life in the study by Scharloo and colleagues (2007). It has also been found that the fewer perceived symptoms an individual has, the better the perceived health (Scharloo et al, 2000).

1.5.5 Illness Perceptions and Anxiety and Depression in COPD

There is the expectation that illness perceptions will be impacted by anxiety and depression. Attributing a psychological factor as a cause of COPD results in increased levels of anxiety and depression (poorer emotional adjustments) (Hoth et al, 2011). Of the 63% of participants in Howard and colleagues' study (2009) who reported a panic attack in the previous year, there were increased levels of anxiety, stronger identity beliefs, and beliefs that their COPD was more chronic. Of the people who had a panic attack in the past month, most believed that there were more severe consequences to their disease and they had stronger emotional representations of their COPD (Howard et al, 2009). There was no significant difference in disease severity between those participants who were classified as non-panickers and those who were panickers (Howard et al, 2009). This study showed that perceived control over their disease was not found to be related to panic tendencies, although those people who had lower perceived control also had a greater disease impact (Howard et al, 2009). In terms of the experience of depression in COPD, those who had symptoms of depression experienced more perceived consequences of their disease, a more chronic timeline, less personal and treatment control, a stronger illness identity, more concern with their COPD, and a higher emotional response (Hyphantis et al, 2015). General psychological well-being is also related to illness perceptions with more positive perceptions leading to better feelings of well-being (Zoeckler et al, 2014).

1.5.6 Changes in Illness Perceptions in COPD

There has been little interest in the longitudinal course of illness perceptions in those with COPD. There was one study that was found to have examined how illness representations change over a one-year period in individuals with COPD (Bonsaksen et al, 2015a). The participants with a diagnosis of COPD were found to have an initial increase in both their understanding of their COPD as well as the degree of personal control that they felt but they were not able to maintain these increases during the four subsequent visits over the year in which they were examined. There were no other illness perception domains that were found to have any significant changes over the one-year study period.

1.6 Summary

- COPD impacts approximately 17% of Canadians aged 35-79.
- The cost of COPD to Canadian society is projected to increase as the prevalence of COPD is also projected to increase.
- Physical activity levels are lower in those with COPD than in age-matched controls.
- Lower levels of physical activity in COPD are associated with increased disease severity, number of comorbidities, increased level of fatigue, higher smoking rates, frailty, female sex, older age, and presence of sarcopenia.
- Increased levels of inflammation and dyspnea are also related to lower physical activity levels in COPD.
- Lower physical activity levels are related to a higher number of acute exacerbations and hospitalizations as well as higher mortality rates.
- Higher levels of anxiety and depression are related to lower levels of physical activity in COPD but attending pulmonary rehabilitation has been shown to help lower these levels of anxiety and depression as well as improve quality of life.
- Pulmonary rehabilitation has both been shown to increase physical activity levels and have no change on activity.

- Both anxiety and depression impact a large number of individuals diagnosed with COPD.
- Higher levels of anxiety and depression have been associated with increased dyspnea, hospital admissions, higher mortality rates, as well as disease severity of COPD.
- Lower levels of quality of life are related to increased COPD severity, less stable COPD, female gender, increased dyspnea, and lower levels of self-efficacy.
- In general, more negative illness perceptions are associated with increased levels of disability, increased somatic symptoms, decreased quality of life, higher levels of anxiety and depression, and lower levels of physical activity in COPD.

1.7 Intentions of This Research

1.7.1 Rationale

The intention of this PhD thesis is to investigate how mental health and general health impact physical activity levels in a COPD population. More specifically, determining whether having poor health status is associated with lower levels of physical activity. In general, those with COPD have lower levels of physical activity despite many different types of interventions. They also tend to have higher levels of anxiety, depression, poorer quality of life, and more negative illness perceptions than the general population. Attempting to investigate determinants of physical activity in a pulmonary rehab population in order to add to and help make sense of the contentious literature is important. Investigating physical activity levels in a COPD population across Canada has not been completed to my knowledge. Determining the interrelationship between these levels of activity and other mental and physical health measures in this large of a sample specific to Canada has also not been completed.

The first portion of this thesis investigates a COPD population attending pulmonary rehab and how physical activity levels and exercise capacity are related to anxiety, depression, and illness perceptions. The second portion looks at a nationwide sample of individuals with an obstructed breathing pattern in order to investigate whether various measures of health and mental health impact physical activity levels. The third portion of the thesis delves into whether the same national obstructed sample differs from a non-obstructed sample with respect to physical activity, health measures, and mental health measures.

1.7.2 Research Objectives

The questions to be addressed by this body of research are as follows:

1. How is physical activity in a COPD population related to anxiety, depression, illness perceptions, quality of life, as well as self-perceived mental health?
2. How is physical activity related to self-perceived health, dyspnea and other respiratory symptoms in COPD?
3. Is there a difference in physical activity and measures of mental and physical health between various levels of airway obstruction from those with no discernable obstruction to those with severe/very severe obstruction?

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Table 1.1 – Summary of Physical Activity and COPD Studies

Authors	Research Question	Participants	Measures	Conclusion
Alahmari et al, 2014	What are the daily step counts for individuals with COPD before, during, and after an AECOPD?	73 participants with COPD were recruited from the London COPD cohort	Age, gender, respiratory symptoms, smoking history, spirometry, peak expiratory flows, pedometer (step count)	Step counts are reduced during non-hospital visit COPD exacerbations and recover typically within 3-4 days after the exacerbations.
Altenburg et al, 2015	Does a counselling program improve PA in COPD patients?	155 participants with COPD were recruited from outpatient practices in the Netherlands	Pedometer, spirometry, fat free mass, 6MWT, short form 36 questionnaire, chronic respiratory questionnaire, dutch exertion and fatigue scale, HADS, perceived physical ability subscale, self-regulation questionnaire for exercise	A 12 week long program to counsel COPD patients on physical activity helps to improve short term physical activity levels and this is maintained after 15 months.
Amorim et al, 2014	Determine how well COPD patients perform their ADLs along with physical activity barriers	92 participants (48 with COPD and 44 controls) were recruited from a respiratory outpatient hospital clinic in Sao Paulo, Brazil	MRC dyspnea rating, Baseline Dyspnea Index (BDI), accelerometry, ADL questionnaire, London Chest Activity of Daily Living scale, 6MWT, spirometry	Individuals with COPD have lower levels of PA compared to controls. Activity levels are influenced by willpower, social influences, and lack of infrastructure. Daily PA and daily steps are related to 6MWD.
Belza et al, 2001	What is the relationship between physical activity, exercise capacity, symptoms, and quality of life in a COPD population?	63 participants with COPD were recruited from an outpatient pulmonary rehab program	Accelerometry, modified activity recall questionnaire, spirometry, 6MWT, walking self-efficacy, dyspnea, multidimensional assessment of fatigue, chronic respiratory disease questionnaire, pulmonary functional status and dyspnea questioinnaire	Accelerometry measured PA is related to 6MWD, severity of airway obstruction, physical health, and self-efficacy for walking.
Benzo et al, 2009	What are the methods used to measure PA quantitatively in COPD?	Literature review	Studies included looked at quantitative evaluation of PA in COPD	PA can be quantified by direct observation, self-reported PA, accelerometry, and the determination of energy expenditure. The use of pedometers and accelerometers is supported in order to quantify daily PA levels and improve maintenance to an exercise program.
Benzo et al, 2015	What are the reasons for not participating in a PA program after hospitalization for AECOPD?	531 participants with COPD were recruited during a hospitalization for an AECOPD	Patients who declined participating in an activity intervention post AECOPD were approached to determine their reasons for not participating. Also measured were PFTs, MRC dyspnea scale, ADO index	Barriers identified included not being interested in an activity program, being too ill, disabled or frail, too busy, having to travel to get to a program, other comorbidities, being too busy, or a lack of social support.
Blumenthal et al, 2016	To determine the value of prognostic factors in patients with COPD	326 COPD outpatients were recruited in Ohio, USA	PFTs, BMI, 6MWD, accelerometry, SGRQ, Beck depression inventory, QoL, inflammation, Charlson Medical Comorbidities Index, GOLD classification	Inflammation, quality of life, depression, pulmonary symptoms, PA levels, and functional status are related to clinical outcomes in COPD (survival, hospitalizations).
Burtin et al, 2015	Does physical activity counselling improve pulmonary rehab outcomes with respect to physical activity?	80 participants with COPD were recruited from a pulmonary rehab program in Leuven	Accelerometry, PFTs, muscle force, 6MWT, chronic respiratory disease questionnaire	PA counselling sessions did not enhance the effect of a pulmonary rehab program on physical activity levels in COPD patients.
Cavalheri et al, 2011	Which daily activities are the most demanding in a COPD population? Which is most accurate: energy expenditure estimates, step counting, accelerometry, or pedometers?	36 participants with stable COPD were recruited from an outpatient respiratory physical therapy clinic in Brazil	Spirometry, 6MWT, MRC dyspnea scale, activities of daily living test, portable gas analysis, accelerometry, pedometry	Stair walking is the most energy demanding activity in this population. Accelerometry is more accurate in COPD patients than pedometry when estimating energy expenditure.

Chambaneau et al, 2016	Provide a description of the dietary habits in COPD patients and compare this to healthy controls	40 participants were recruited (20 control, 20 COPD) from a French Institution	Epidemiological questionnaire, SES, smoking status, spirometry, body mass, BMI, fat mass, fat free mass, depression (Beck Depression Inventory), quality of life (French VQ11), physical activity (Baecke), nutritional status/dietary intake	Those with COPD had higher levels of depression, lower quality of life, lower physical activity levels, lower caloric intake, and lower fat free mass index than controls. Beck depression inventory score was correlated with quality of life.
Chawla et al, 2014	Does functional status/physical activity impact hospital readmission for COPD?	54 participants with COPD were recruited from an inpatient hospital in Connecticut	Spirometry, MRC dyspnea scale, COPD Assessment Test, 6MWT, accelerometry, hospital readmissions	Having less than 60 minutes of higher intensity PA per day was a predictor for 30-day hospital readmission for AECOPD. There was an increase in PA levels after hospitalization for those who were not readmitted and a decrease in PA for those who were.
Cruz et al, 2014	Does the use of activity monitors improve PA levels during pulmonary rehab?	16 participants with COPD were recruited from 2 primary care centers in Portugal	Accelerometry, spirometry, MRC dyspnea scale, 6MWT	The use of accelerometers to help provide feedback on PA in individuals with COPD can improve their activity levels.
Danilack et al, 2014	What are the reasons why COPD patients are not engaging in walking and how is this related to daily step counts?	102 participants with COPD were recruited from veterans facilities in Boston	BMI, comorbidities, smoking status, medication use, oxygen therapy, pulmonary rehab participation, spirometry, MRC dyspnea scale, SGRQ, accelerometry, reasons for not walking	A lower daily step count is related to the presence of COPD related reasons to avoid walking. These reasons include becoming SOB, needing to use oxygen, and requiring inhalers.
de Albuquerque et al, 2016	Does a pulmonary rehab program improve exercise performance in COPD patients with severe hyperinflation?	22 participants with COPD were recruited	Spirometry, 6MWT, incremental cycle ergometer exercise test	COPD patients with severe hyperinflation can improve their exercise capacity with participation in an exercise program. This is done through decreasing respiratory drive , thus reducing lung volumes and, therefore, dyspnea.
Demeyer et al, 2014	What is the impact of various analysis techniques on the effect of intervention post pulmonary rehab?	57 participants with COPD were recruited from an outpatient pulmonary rehab program	Spirometry, 6MWT, accelerometry	When assessing daily step counts and time in light intensity PA, at least 4 weekdays need to be assessed with a minimum wear time of 8 hours is required for accurate results.
Demeyer et al, 2016	What are the differences in physical activity based on severity of COPD?	136 participants with COPD were recruited from the PROactive project in Europe.	Spirometry, 6MWT, accelerometry, MRC dyspnea score, COPD assessment test, clinical COPD questionnaire, exacerbation history	Those at highest risk as measured by GOLD classification also have the most decreased physical activity. The MRC dyspnea score may be one of the most useful scales to help predict physical activity levels.
Di Marco et al, 2014	What are daily PA levels like in the presence or absence of depression?	70 participants with COPD were recruited from an outpatient department in Italy	Clinical history, PFTs, ABGs, MRC dyspnea scale, accelerometry, CPET, 6MWT, BMI, frat free mass, HADS, SGRQ,	COPD patients with depression have lower daily PA levels and maximum exercise capacity compared to non-depressed COPD patients.
Donaire-Gonzalez et al, 2013	What is the typical pattern of PA in a COPD patient? Does this pattern differ based on severity of obstruction?	177 participants with stable COPD were recruited from the PAC-COPD cohort	Accelerometry, self-reported PA, smoking, comorbidities, dyspnea, SGRQ, spirometry, ABGs, BMI, fat free mass, 6MWT	All COPD patients, regardless of severity, participate in bouts of moderate to vigorous intensity PA. These bouts are fewer and shorter in those with severe to very severe obstruction.
Donaire-Gonzalez et al, 2015	Studied the intensity and quantity of PA required to prevent hospitalizations for COPD.	177 participants with COPD were recruited from a previous project in teaching hospitals in Spain	Accelerometry, COPD hospitalizations, pharmacological and non-pharmacological treatment, smoking status, comorbidities, quality of life, dyspnea, PFTs, exercise capacity, inflammatory markers, and lung density/structure	High-intensity PA does not reduce the risk of COPD hospitalizations but a larger quantity of lower-intensity activity does.
Duenas-Espin et al, 2016	How does anxiety and depression impact PA levels in people with COPD?	220 participants with COPD were recruited from across 5 European countries	Age, sex, ethnicity, marital status, SES, HADS, accelerometry	Depressive symptomology is related to a reduced level of physical activity in people with COPD.

Durheim et al, 2015	What are the changes in 6MWD and step counts during AECOPD hospitalizations categorized by COPD severity? Is PA related to time-to-first AECOPD or mortality?	326 participants were recruited from the INSPIRE-II trial in Ohio	SGRQ, MRC dyspnea scale, hospitalization history, accelerometry, 6MWT, medical encounters	6MWD and accelerometry measured PA are related to first AECOPD hospitalization, moreso than GOLD classification. The same relationship is true for mortality risk.
Durr et al, 2014	Is physical activity related to quality of life in COPD patients?	87 participants with stable COPD were recruited from a hospital in Switzerland	COPD assessment tool, SGRQ, spirometry, 6MWT, number of AECOPD in 12 months, age, gender, height, weight, smoking status, comorbidities, accelerometry	Daily step counts and 6MWD are related to quality of life.
Elbehairy et al, 2015	To determine if chronic bronchitis patients have increased SOB and worse exercise tolerance than COPD controls	40 participants with COPD (20 chronic bronchitis, 20 not) were recruited	PFTs, sputum induction, CT scans of chest, incremental cycle ergometry exercise test	Chronic bronchitis phenotype patients have increased levels of dyspnea and worse quality of life than controls
Eliason et al, 2011	Study exercise capacity, physical activity, and body composition in COPD patients compared to healthy controls	61 participants (44 COPD, 17 controls) were recruited from a primary health care centre in Sweden	PFTs, 6MWT, body composition (weight, skinfolds), accelerometry	Higher levels of severity of COPD are related to lower levels of physical activity, compared with healthy controls
Esteban et al, 2010	What impact does PA levels have on HRQOL in COPD patients over a 5 year span?	611 participants with COPD were recruited from outpatient clinics in Spain	HRQOL, self-reported PA, comorbidities	Those individuals who started out with low PA or whose PA was reduced over 5 years had lower HRQOL while those who increased their PA or maintained higher levels had higher HRQOL.
Esteban et al, 2016	To assess how physical activity changes during moderate to severe AECOPD requiring a visit to the ED.	2487 participants with an AECOPD were evaluated at EDs in hospitals in Spain.	Spirometry, ABGs, Glasgow Coma Scale, Charlson Comorbidity Index, questions regarding PA, health, and dypsnea	Physical activity levels amongst individuals with COPD coming to the ED for an AECOPD are quite variable. In general, anything influencing the clinical condition of the patient will impact their physical activity levels.
Furlanetto et al, 2010	How accurate are the Digiwalker pedometer and the SenseWear multisensor when analyzing number of daily steps and energy expenditure in both COPD and healthy individuals.	60 participants (30 with COPD, 30 controls) were recruited from an outpatient respiratory physical therapy clinic in Brazil	Spirometry, 6MWT, step size, treadmill walking protocol, accelerometry, pedometry, portable gas analyzer	The SenseWear multisensor had a better energy expenditure estimation in both COPD and controls than the Digiwalker pedometer. Only the pedometer was found to be accurate for step counts at high walking speeds.
Garcia-Aymerich et al, 2004	To assess PA levels and the determinants of PA in a COPD population.	346 emergency room and hospital admitted COPD patients with an acute exacerbation of COPD in a Spanish hospital	Spirometry, blood gases, socioeconomic status, HRQOL (SF-12), physical activity (Minnesota leisure time physical activity questionnaire)	Lower energy expenditure was related to older age, increased dyspnea, lower HRQOL, increased number of acute exacerbation hospitalizations, and use of LTOT.
Garcia-Rio et al, 2009	How does dynamic hyperinflation and exercise tolerance impact physical activity in those with COPD?	110 participants with COPD (moderate to severe)	Accelerometry, 6MWT, incremental exercise test, MRC dyspnea scale, SGRQ, BODE index, ABGs, PFTs	Physical activity levels were related to dynamic hyperinflation in study participants. It is also related to exercise tolerance (6MWD).
Garcia-Rio et al, 2012	What is the prognostic value of physical activity as measured by accelerometry in risks of mortality, decline	173 participants with moderate to severe COPD were recruited	MRC dyspnea scale, SGRQ, BODE index, smoking status, comorbidities, accelerometry, ABGs, PFTs, 6MWT, incremental cycle ergometer exercise test	Accelerometry can be used as a prognostic indicator for mortality and AECOPD hospitalizations.

	in lung function, and risk of hospitalizations for AECOPD?			
Gouzi et al, 2011	To determine physical activity levels in COPD patients and determine when they start to be reduced in correlation with age of onset of breathlessness etc.	129 participants with COPD were recruited from a pulmonary rehabilitation program	Modified Baecke questionnaire, actimetry, QUANTAP system (determines lifetime PA levels), age at onset of dyspnea, age at diagnosis, PFTs, ABGs, 6MWT, incremental cycle ergometry exercise test, maximal voluntary muscle contraction	The participants had normal activity levels 20 years previous to the study but these levels became reduced at an early age (10 years prior to those that are sedentary but healthy). The reduction in PA occurred prior to receiving a diagnosis or becoming dyspneic.
Hartman et al, 2013	Determine the level of physical activity in those with COPD as well as amount of time spent sitting. Also assess the factors associated with physical activity.	115 participants were recruited from outpatient clinics in the Netherlands	Accelerometry, spirometry, MRC dyspnea scale, incremental cycle ergometer exercise test, 30 second sit to stand test, fat free mass, BODE index, social support, depression, illness perceptions, self-efficacy, sleep quality, quality of life	There are lower levels of PA the more severe the airway obstruction is. Sitting time was not dependent on COPD severity.
Jehn et al, 2011	Is accelerometer data related to disease severity in COPD?	117 participants with COPD were recruited from the PROMISE study in Switzerland.	Spirometry, medical history, quality of life MRC dyspnea scale, chest x-ray, 6MWT, accelerometry, BODE index, sputum samples	Daily walking time is associated with both disease severity and 6MWD. It can also be used to predict BODE score (prognosis).
Johnson-Warrington et al, 2014	Examine the differences in exercise capacity and PA between COPD and controls with SOB	102 participants were recruited (83 COPD, 19 controls with MRC grade 2) from a previous randomized controlled trial	Spirometry, MRC dyspnea scale, incremental shuttle walk test, accelerometry	Even though the controls had a similar MRC dyspnea score, the participants with COPD had significantly lower levels of physical activity and exercise capacity.
Jones et al, 2015	Examined the prevalence of sarcopenia in COPD along with its impact on health status and exercise capacity. Can sarcopenia be reversed by participation in pulmonary rehab?	622 stable COPD outpatients from a respiratory clinic in the United Kingdom	Skeletal muscle mass, grip strength, 4 meter gait speed test, incremental shuttle walk test, 5 repetition sit to stand, short physical performance battery, quadriceps maximum contraction, SGRQ, Minnesota leisure-time PA questionnaire, accelerometry, BODE index and charlson index for comorbidities	Prevalence of sarcopenia was 14.5%. The following was associated with sarcopenia: low muscle mass, age, increased airway obstruction, decreased quads strength, lower exercise capacity, decreased functional performance, lower levels of physical activity, and decreased health status. The presence of sarcopenia did not impact the response to PR. PR can help reverse sarcopenia in some patients.
Katajisto et al, 2015	Studied the use of maintenance medications in active vs inactive COPD patients.	719 participants with COPD were recruited from the Finnish Chronic Airway Disease Cohort	Medical history, spirometry, height, weight, smoking status, physical activity questionnaire, use of COPD medications, COPD exacerbations,	Physical inactivity is not a result of poor adherence to maintenance medications but is related to number of exacerbations treated via hospitalization or at home.
Kawagoshi et al, 2013	Measure the various times spent walking as well as position changes in older adults with COPD	46 participants (26 COPD, 20 controls) were recruited for this study	Accelerometry, PFTs, quadriceps force, 6MWD, Borg Dyspnea scale, MRC dyspnea scale, chronic respiratory disease questionnaire (QOL)	Both fast and slow walking are reduced in COPD patients as well as how often postural changes are made.
Kawagoshi et al, 2015	Compare the long term efficacy of a pulmonary rehab program with and without the use of a daily pedometer for feedback.	27 participants with stable COPD were recruited from a home based pulmonary rehab program in Japan	Breathing retraining exercises, walking, resistance exercises, pedometers, accelerometry, spirometry, quadriceps force, 6MWT, BODE index, MRC dyspnea scale, chronic respiratory disease questionnaire	PA was improved in the participants in the home based program with use of a pedometer over and above the group that did not use a pedometer, although both groups did have an improvement in PA.
Kim & Kim, 2014	To determine interventions that are gender specific in order to improve HRQOL in COPD patients.	751 participants (556 male, 195 female) with COPD were recruited in the KNHANES study in Korea	HRQOL, age, education, SES, marital status, COPD severity, comorbidities, smoking status, self-reported PA	Females with COPD have higher HRQOL than their male counterparts. Both men and women's HRQOL was impacted by physical activity level.
Kortianou et al, 2015	Are less physically active patients with COPD more limited	18 participants with COPD were recruited from a previous study on	PFTs, ABG, accelerometry, 4-minutetreadmill constant speed walking test, inspiratory	The ability to increase tidal volume and maintain inspiratory reserve

	by tidal volume expansion and inspiratory reserve than more active ones?	physical activity limitations	capacity, chest wall volume measurements	volume during exercise is related to increased physical activity levels.
Loprinzi et al, 2014	To determine if inflammation levels in COPD can be reduced by physical activity	238 participants with self-reported COPD were included from NHANES data	WBC, neutrophils, smoking status, accelerometry, BMI, homocysteine levels, high sensitive c-reactive proteins	Physical activity levels and inflammatory markers are inversely related in those with COPD.
Mador et al, 2011	Does PA immediately increase in COPD patients after participating in pulmonary rehab?	32 participants (24 COPD, 8 controls) were recruited from a Veterans Affairs clinic in New York State	PFTs, incremental cycle ergometer exercise test, quadriceps strength, accelerometry, chronic respiratory questionnaire (QOL)	Activity levels were increased after participating in pulmonary rehab but exercise capacity and muscle strength was unchanged. Level of change in activity levels was related to level of obstruction.
McNamara et al, 2014	Compare PA in COPD pop'n of those with and without comorbidities and those without COPD	75 participants (25 per group) recruited from a tertiary public hospital in Australia	Accelerometry (physical activity and sedentary time), PFT's, dyspnea, 6MWT, physical function, health related quality of life	Those with COPD and comorbidities had more dyspnea, lower functional performance and quality of life, as well as lower exercise capacity compared to the other 2 groups. This same group had higher sedentary time and lower physical activity duration time.
Mendoza et al, 2015	Will a pedometer based program improve daily step counts in stable COPD patients over a 3 month period?	97 participants with stable COPD were recruited from another randomized controlled trial in a hospital in Chile	Spirometry, MRC dyspnea scale, SGRQ, COPD assessment test, 6MWT, daily step count (pedometer),	A pedometer based PA program can improve physical activity levels in COPD patients over a 3 month span as well as improve their quality of life.
Minakata et al, 2014	Determined the various levels of intensities of PA in COPD patients	64 participants (43 COPD, 21 controls) were recruited from an outpatient clinic in a Japanese University Hospital	Spirometry, accelerometry, dyspnea (MRC dyspnea scale), BODE index, 6MWT	Physical activity of all intensities is related to FEV_1. There are more reductions in PA at higher intensities of activity.
Miravitlles et al, 2014	What is the daily walking time for COPD patients? How is this related to QOL and psychosocial factors?	4574 participants with COPD were recruited from the INSEPOC study in Spain	Age, gender, BMI, smoking habits, spirometry, self-reported PA, comorbidities, HRQOL, HADS	Mean daily walking time was 74 minutes. Walking time was related to COPD severity, depression, and a lower health status.
Mittal et al, 2016	To determine how prevalent frailty is in a chronic respiratory population and if a measure of gait speed can be used to screen for frailty	120 patients with COPD, asthma, pulmonary hypertension, and interstitial lung disease from general respiratory clinics in Texas, USA	Frailty, physical activity (Minnesota leisure time activity questionnaire), 15 foot walk time, grip strength, 100 foot walk test	Frail patients had increased weight loss, decreased grip strength, exhaustion, lower gait speed, lower levels of activity, higher number of falls, and a higher number of hospitalizations. Gait speed can be used to screen for frailty.
Miyamoto et al, 2014	How efficacious is pulmonary rehabilitation in respiratory patients who are victims of air pollution?	29 participants (11 with COPD and 18 with asthma) were recruited from pollution related organizations in Japan	Diagnosis, oxygen therapy, dyspnea, PFTs, muscle force, exercise capacity, quality of life, depression, ADLs, accelerometry	Participants experienced reduced levels of dyspnea and improved exercise capacity after attending pulmonary rehabilitation.
Moy et al, 2009	What is the feasibility of a program to monitor daily PA over 2 weeks? How much PA to individuals with COPD participate in? Is there a relationship between daily steps and activity checklist items?	17 participants with stable COPD were recruited from a pulmonary clinic in Boston	Accelerometry, physical activity checklist, 6MWT, spirometry, BODE index, comorbidities, HRQOL, MRC dyspnea scale, Beck depression inventory,	Daily PA in COPD can be measured both by accelerometry and activity checklist. Steps per day was related to HRQOL, FEV_1, number of comorbidities, and BODE index.
Moy et al, 2016	How efficacious is the taking healthy steps program on	239 participants (154 treatment, 84 control) with stable COPD were	MRC dyspnea scale, SGRQ, pedometry,	There is an initial improvement in step count after 4 months of internet

	improving PA and QOL after 12 months?	recruited from a veterans database in the US		based intervention but this is not maintained at 12 months.
Nguyen et al, 2011	To determine the validity of a new activity monitor as well as what the optimal number of monitoring days are required with use in COPD patients	17 participants with COPD were recruited from a pulmonary rehabilitation program and 60 healthy adults were recruited from the community via flyers	Accelerometry, spirometry, dyspnea (MRC scale), 6MWT, BODE index, incremental cycle ergometer exercise test, HRQOL (MOS-SF-36 and SGRQ)	COPD patients had fewer steps per day and a smaller amount of time in high intensity activity and more time in low intensity activity. Those with COPD operate at lower intensities than their healthy counterparts
Nguyen et al, 2013	What is the relationship between anxiety, depression, and physical activity in a COPD population?	148 participants with stable COPD were recruited from CASCADE study in Seattle	Spirometry, 6MWT, accelerometry, HADS, shortness of breath questionnaire	Anxiety is related to increased PA levels in those with COPD.
Nguyen et al, 2014	Does regular PA result in a lower risk for 30 day readmission for COPD exacerbation?	6042 participants with COPD were recruited from medical centers in Southern California	30 day readmission, self-reported PA	Any level of moderate to vigorous PA is related to a lower risk of 30 day readmission for COPD exacerbation.
Patel et al, 2007	How valid and reproducible is a physiologic activity monitor when looking at energy expenditure in a COPD population?	8 participants with COPD were recruited from an emphysema research registry in Pittsburgh	6MWT, accelerometry, portable gas analyzer	This accelerometer is accurate and reproducible in a COPD population when estimating energy expenditure in slow to moderate speed walking.
Pitta et al, 2005	Compare activity in those with COPD with controls	62 patients with COPD (mild to very severe) and 26 controls	Accelerometry, PFTs, quadriceps force, hand grip dynamometry, 6MWD, VO2max	COPD patients had lower levels of physical activity, specifically lower walking time, standing time, and lower levels of activity intensity and they had larger times spent sitting and lying down. 6MWD is correlated with standing time and walking time in those with COPD meaning that those with lower 6MWD have lower levels of PA.
Pitta et al, 2008	Examine the accelerometry data in pulmonary rehab patients with COPDafter 3 and 6 months of the program.	29 participants with COPD were recruited from a pulmonary rehab program	Spirometry, isometric quadriceps force, incremental cycle ergometer test, chronic respiratory disease questionnaire, pulmonary functional status and dyspnea questionnaire, accelerometry	Patients did not spend more time walking every day after a 3 month pulmonary rehab program. This change did occur after 6 months of pulmonary rehab.
Saglam et al, 2015	What are the differences between hypoxemic and non-hypoxemic COPD patients with respect to physical activity, quality of life, and functional capacity?	39 participants with stable COPD were recruited for this study	BMI, spirometry, ABGs, 6MWT, International Physical Activity Questionnaire, accelerometry, SGRQ	Both hypoxemia and a decline in lung function are related to a reduced exercise capacity in COPD. Hypoxemia alone is related to diminished lung functions, physical activity levels, and functional capacity.
Sant'Anna et al, 2012	How valid and reproducible is a new accelerometer in a COPD population?	30 participants with stable COPD were recruited from a respiratory physical therapy program in Brazil	Walking circuit protocol, ADL protocol, 2 types of accelerometer	The new accelerometer's results are reproducible with a COPD population when compared to an accelerometer that had previously been validated in this population.
Saunders et al, 2015	How does the use of pedometers impact physical activity levels in COPD patients after completing pulmonary rehab?	190 participants with COPD were recruited from a pulmonary rehab program across Canada	Spirometry, 6MWT, height, weight, pedometer,	There are 2 different groups identified with respect to physical activity after pulmonary rehab: one who had high PA both before and after rehab while the other had low PA both before and after rehab. Those who are more likely to be active are women who are currently employed and who had

				higher exercise capacity prior to pulmonary rehab.
Schonmann et al, 2015	How does PA and exercise capacity impact number of AECOPDs?	210 participants with COPD from the Obstructive Pulmonary Disease Outcomes Cohort of Switzerland were used in this study	Age, gender, BMI, smoking history, MRC dyspnea scale, comorbidities, medical records, Accelerometry, 6MWT, self-reported number of AECOPD, PFTs, ABGs	PA levels measured by accelerometry and exercise capacity measured by 6MWT did not impact number of AECOPDs the participants experienced. Level of airflow obstruction was related to number of exacerbations.
Schuz et al, 2015	How does anxiety and depression impact self-management skills and physical activity in COPD patients?	182 participants with COPD were recruited from general practices in Tasmania	Accelerometry, self-management knowledge, HADS,	Health mentoring by health care professionals can change PA levels but not in those with clinically relevant anxiety or depression.
Steele et al, 2000	To measure the validity, reliability and stability of a new accelerometer for use in COPD.	47 participants with stable COPD were recruited prior to entrance to a pulmonary rehab program	Accelerometry, 6MWT, spirometry, dyspnea, self-efficacy, modified activity recall questionnaire	Accelerometry gives an idea of daily function and is associated with exercise capacity and severity of airway obstruction. It is also associated with self-efficacy for walking and shortness of breath.
Thorpe et al, 2014	What are the enablers of and barriers to PA 2 months post hospital admission for AECOPD?	28 participants with COPD were recruited from a hospital in South Australia 2 months after being admitted for an AECOPD	Structured interviews	Barriers identified included: age, previous negative experience, access to oxygen therapy, comorbidities, health, and environment. Enablers included, social support, routine, goals and motivation, access to equipment and health professionals.
Todt et al, 2014	Examine PA levels in those with stable COPD and look at relationship with fatigue, body composition, and symptom burden	101 participants recruited from an outpatient clinic in two hospitals in Sweden	Self-reported physical activity (IPAQ-S), fatigue, dyspnea (MRC), anxiety & depression (HADS), symptom burden (MSAS), body composition, 6MWT, PFT's, grip strength, timed stand test, inflammation, health status (ICF-checklist)	Higher fatigue was related to lower PA levels. Low PA was related to larger symptom burden, dyspnea, more time to stand, and lower grip strength. PA was correlated with 6MWD, dyspnea, mental, physical, and emotional health, smoking history, fatigue, grip strength, HADS depression, and exacerbation rates.
Torres-Sanchez et al, 2016	How efficacious is a multimodal exercise program in obese COPD patients during a hospitalization?	49 participants hospitalized with an AECOPD were recruited from Spanish hospitals	Spirometry, SGRQ, level of independence, physical strength and exercise capacity, dyspnea, HADS	An inpatient multimodal exercise program helps to improve muscular strength as well as exercise capacity in an obese COPD population hospitalized for an AECOPD.
Tsai et al, 2016	Do physical activity levels increase the longer an individual with COPD is away from hospitalization?	50 participants with COPD were recruited from an inpatient respiratory ward in Australia with an AECOPD.	Accelerometry, PFTs, 6MWT, Functional Performance Inventory, COPD assessment test, MRC dyspnea scale, HADS,	There are low physical activity levels for those hospitalized with an AECOPD, which did not improve throughout the hospitalization. PA did improve after initial discharge from hospital but didn't improve further in the next 6 weeks.
Vaes et al, 2014	What are the differences in changes in PA levels over time in those with and without COPD? What are the determinants for these PA levels?	1004 participants were recruited (1270 with COPD and 8734 controls) from the Copenhagen City Heart Study	Self-reported PA, spirometry, SES, smoking habits, comorbidities	Individuals with COPD have lower self-reported physical activity levels than those without COPD. Their PA levels have a tendency to decrease over time. Those with COPD also have higher rates of mortality.
Valenza et al, 2016	To investigate the power of prediction and cutoffs of physical activity in order to determine level of frailty in those with stable and exacerbated COPD	312 participants (212 with COPD and 100 controls) admitted to a Pulmonary Medicine Service in Spain	Independence in functional activities (Barthel index), cognition (MMSE), comorbidities (Charlson), exacerbations in a year, quality of life (EuroQol-5D), GOLD classification, balance (one leg stance test), 2 minute step in place, fatigue (Piper), frailty index, physical activity (modified Baecke)	Frailty was higher in those with COPD. Balance and functional capacity is worst in those in a COPD exacerbation. Frailty is associated with decreased physical activity in all groups.

van Remoortel et al, 2013	Examine physical activity levels in COPD as well as clinical characteristics associated with PA	124 participants were recruited (59 COPD, 65 smoking controls) were recruited	Accelerometry, dyspnea, PFTs, muscle strength, and exercise capacity	COPD participants had significantly lower PA levels than smoking controls. Diffusion capacity for carbon monoxide and 6MWD were predictors for PA in COPD.
Vorrink et al, 2011	How does COPD impact duration, intensity, and counts of daily physical activity? Does COPD severity also impact these measures?	Literature review so no participants were directly involved. 11 studies were included.	GOLD severity, daily physical activity (measured objectively)	Individuals with COPD have reduced physical activity levels compared to controls with respect to duration, intensity, and counts of daily PA.
Waschki et al, 2011	What is the prognostic value of accelerometry measured PA and systemic inflammation when predicting mortality?	170 participants with stable COPD were recruited from an outpatient department in Germany	Accelerometry, spirometry, echocardiography, systemic inflammatory markers, vascular Doppler sonography (PAD), BMI, fat free mass, MRC dyspnea scale, SGRQ, Beck Depression inventory, BODE index, ADO index, mortality	Accelerometry measured PA is the best predictor for mortality when compared to other ways to assess COPD prognosis. Other prognostic indicators included adiponectin levels, leptin levels, right ventricular dysfunction, and vascular status.
Waschki et al, 2015	To assess PA changes based on severity of COPD, health status, exercise tolerance, inflammation level, and skeletal muscle over a 3 year time period.	200 outpatient COPD patients were recruited from a Pulmonary Research Institute in Germany	Accelerometry, spirometry, 6MWT, SGRQ, muscular status (bioelectrical impedeance), inflammation, fat free mass, and muscle depletion	Daily physical activity levels decreased over 3 years in this COPD population. Decline in FEV_1 and increase in SGRQ score were related to decreased PA. A lower level of PA that is maintained over time is related to faster decline in exercise tolerance and muscle mass.
Watz et al, 2008	Can reductions in physical activity be explained by COPD extrapulmonary impacts as well as comorbidities?	170 participants with COPD were recruited from an outpatient research institute in Germany	BODE index, echocardiography, markers of inflammation, beck depression inventory, BMI, hemoglobin levels, accelerometry	Reduced levels of physical activity are related to increased levels of airway obstruction, increased inflammatory markers, and cardiac dysfunction.
Wilson et al, 2015	How efficacious is a low intensity maintenance program on HRQOL after participating in a previous pulmonary rehab program?	148 participants with COPD were recruited from a pulmonary rehab program in the UK	Spirometry, incremental shuttle walk test, HADS, Euro Qol test, skinfold thickness	A maintenance program consisting of a 2 hour session every 3 months does not help to improve QOL or physical activity in COPD patients after 12 months.
Zhang et al, 2015	Comparison of those with and without chronic bronchitis in terms of exercise capacity and dynamic hyperinflation	82 participants (45 without chronic bronchitis and 37 with chronic bronchitis) were recruited from a hospital in Beijing	BMI, smoking history, MRC dyspnea scale, COPD assessment test, HADS, 6MWT, PFTs, incremental cardiopulmonary exercise test, inflammatory markers	Those with chronic bronchitis and a lower exercise capacity than those without. This was because they had increased dynamic hyperinflation while exercising.

Table 1.2 – Summary of Anxiety and Depression and COPD Studies

Authors	Research Question	Participants	Measures	Conclusion
Ajmera et al, 2015	What is the prevalence of multimorbidity in COPD patients?	19060 participants with COPD were selected from Medicaid files	Pharmacological treatments, comorbidities, sex, race, age, education, employment status	There is higher prevalence of multimorbidity in those who have low incomes, are non-elderly and have poor medication management in this COPD population. Comorbidities identified included hypertension, musculoskeletal issues, diabetes, schizophrenia, depression, increased lipids, anxiety, cardiovascular issues, and bipolar disease.
Al-Gamal & Yorke, 2014	How does shortness of breath impact COPD patients?	67 participants with COPD were recruited from Jordanian teaching hospitals	Dyspnea 12 scale, HADS, gender, age, education level, income, employment status, comorbidities, smoking history	Anxiety and depression was found in clinically significant levels in both COPD patients and their spouses. Those who have a higher level of dyspnea are more likely to have a higher HADS score.
Amiri et al, 2012	How are anxiety and COPD related?	Review article		Generalized anxiety disorder is common in COPD patients and it decreases quality of life in these patients. It can also lend to the development of AECOPD. Group classes such as pulmonary rehab can help with symptoms of anxiety but medication may also be necessary
An et al, 2010	How useful is the BODE index when analyzing anxiety and depression in a COPD population?	256 participants with stable COPD were recruited from the respiratory medicine department in 2 Beijing hospitals	Demographics, spirometry, HADS, SGRQ, MRC dyspnea scale, 6MWT, BODE index	The BODE index can be useful in predicting anxiety and depression symptoms in individuals with stable COPD. This is likely because it measures symptoms that are risk factors for anxiety and depression.
Atlantis et al, 2013	Can the presence of anxiety or depression impact COPD outcomes and mortality or does the presence of COPD predict anxiety or depression?	Review article on 16 studies	Descriptive data synthesis	There are poorer COPD outcomes and higher rates of mortality associated with those who have depression or anxiety in the COPD population.
Balcells et al, 2010	How are HRQOL and anxiety and depression related in a COPD population?	337 participants with stable COPD were recruited from teaching hospitals throughout Spain	SGRQ, HADS, Barthel index (ADLs), demographic information, MRC dyspnea scale, Charlson comorbidity index, PFTs	Both anxiety and depression are related to a reduction in HRQOL either alone or together.
Bentsen et al, 2014	How are anxiety, depression and QOL related in COPD patients?	100 participants with COPD were recruited from a pulmonary rehab program in Norway	Age, sex, comorbidities, HADS, numeric pain rating, SGRQ, quality of life scale, spirometry, incremental shuttle walk test	31% of participants had anxiety, 13% had depressive symptoms, and 45% experienced pain. Younger patients with higher levels of anxiety had poorer QOL as well as those with poorer physical function and higher depression.
Bhattacharya et al, 2014	Do individuals with anxiety and/or depression have a greater risk for other comorbidities (i.e. COPD)?	33242 participants data were pooled from the Medical Expenditure Panel Survey in the US	Presence of chronic conditions, presence of anxiety and/or depression, gender, age, race, SES, BMI, smoking status, lack of physical activity	Presence of anxiety and depression were both related to a higher risk for COPD.
Borges-Santos et al, 2015	How does anxiety and depression influence shortness of breath and breathing mechanics in a COPD population?	54 participants with COPD were recruited from an outpatient respiratory department in a university hospital	Spirometry, HADS, MRC dyspnea scale, clinical COPD questionnaire, ABGs, thoracoabdominal mechanics and kinematics, respiratory muscle activity	Anxiety and depression increase the sensation of shortness of breath but do not affect breathing pattern or respiratory mechanics either during physical activity or at rest.
Bratas et al, 2010	How does a 4 week pulmonary rehab program impact quality of life, psychological distress, and exercise capacity in a COPD population?	136 participants with COPD were recruited from pulmonary rehab programs in Norway	Spirometry, 6MWT, SGRQ, HADS, comorbidities, demographics	Improvements in QOL, exercise capacity, and symptoms of depression are seen after participation in a 4-week inpatient pulmonary rehab program. This improvement is more dramatic in those with mild to moderate COPD.
Bratek et al, 2015	What are the scores for anxiety, depression, and	59 participants (24 COPD, 17 asthma) were recruited from a	MMSE, trail making test, beck depression inventory, state trait	Those with asthma and COPD have higher levels of anxiety, depression, and cognitive dysfunction than their healthy counterparts.

	cognition in patients with asthma or COPD?	pulmonary department in Silesia	anxiety inventory, spirometry, sputum induction	There is an association between severity of airway obstruction and neuropsychological status with worse obstruction being related to lower cognition and higher levels of anxiety and depression.
Catalfo et al, 2016	How does aerobic exercise impact symptoms of anxiety and depression as well as other physical parameters in COPD patients?	52 participants with COPD were recruited from a pulmonary rehab program in Italy	Spirometry, 6MWT, MRC dyspnea scale, accelerometry, Hopkins symptom checklist, HADS, Hamilton depression rating scale, state-trait anxiety inventory, raven's colored progressive matrices, rey auditory verbal learning test, , trail making test	Pulmonary rehab programs can improve symptoms of both anxiety and depression in COPD patients.
Chang et al, 2015	What are common descriptors used for symptoms amongst respiratory patients? Do they differ based on diagnosis?	136 respiratory outpatients were recruited for this study with COPD (68), asthma (22), ILD (8), respiratory muscle weakness (11), and other (10)	PFTs, MRC dyspnea scale, HADS, 15 item descriptive questionnaire of breathing discomfort, walk test, SpO2	All groups describe breathing as being effortful but there was no symptom found to be specific to COPD. COPD patients had a higher HADS-anxiety score than the other respiratory patients.
Coventry, 2009	What is the current thinking on the use of pulmonary rehab in treating depression and anxiety in a COPD population?	Review article		Pulmonary rehab can help to manage psychological symptoms in a COPD population as there is a large proportion of the COPD population that is impacted by anxiety and depression.
De, 2011	How prevalent and how severe is depression in COPD?	100 participants with stable COPD were recruited during outpatient respirology appointments in India	Spirometry, PHQ-9	Symptoms of depression are common in COPD with increased levels of depression in more severe COPD.
de Carvalho Lopes Orlandi et al, 2016	How does depression diagnosed by MINI rather than by symptoms influence how depression impacts functional capacity and QOL in COPD patients?	54 participants (30 men and 24 women) were recruited from a hospital	History of depression, hospitalizations, spirometry, MINI for depression, strength, 6MWT, respiratory muscle strength, SGRQ, MRC dyspnea scale	Depression was not related to quality of life or functional capacity in this COPD population. There is a large proportion of individuals with COPD experiencing depression, especially in women.
de Voogd et al, 2010	How is anxiety related to shortness of breath on exertion in COPD?	90 participants with stable COPD were recruited from a pulmonary rehab program in the Netherlands	HADS, modified borg scale for dyspnea, CPET via cycle ergometry, BMI, muscle force, PFTs	General symptoms of anxiety is related to shortness of breath on exertion.
di Marco et al, 2006	How prevalent is anxiety and depression in a COPD population both total and broken down into severity level?	202 participants with COPD were recruited from a respiratory unit in Italy	State trait anxiety inventory, Zung self-rated depression scale, SGRQ, MRC dyspnea scale,	Both anxiety and depression are common in the COPD population, regardless of the severity of their disease. Anxiety and depression are related to a lower quality of life and female sex.
Doyle et al, 2013	How are anxiety and depression related to functional capacity in a COPD population?	162 participants with COPD were recruited in the INSPIRE-II trial	Brief fatigue inventory, STRQ, shortness of breath questionnaire, Beck depression inventory, state-trait anxiety inventory, spirometry, 6MWT, Charlson comorbidity index, use of medications, age, gender, height, weight, marital status, education, smoking status	COPD together with anxiety and depression are related to higher levels of fatigue, worse respiratory symptoms, and increased dyspnea.
Duenas-Espin et al, 2016	How does anxiety and depression impact physical activity levels in COPD patients?	220 participants with COPD were recruited from hospitals and rehab centers in several European centers	HADS, accelerometry, smoking history, COPD exacerbations, shortness of breath, COPD assessment test, comorbidities, BMI, fat free mass, spirometry, 6MWT	There is a decreased level of physical activity after 6 months with symptoms of depression.

Einvik et al, 2015	What are the symptoms of anxiety and depression in individuals hospitalized with dyspnea?	185 hospital inpatients (53 COPD, 80 CHF, 52 other)	New York Heart Association functional class, respiratory rate, ECG, vitals, inflammation, HADS	Symptoms of anxiety and depression are most common in those with a diagnosis of COPD of CHF being hospitalized with acute dyspnea.
Eisner et al, 2010	Does the presence of COPD impact the risk of anxiety symptoms and does this, in turn, lead to worse health outcomes?	1504 participants (1202 with COPD and 302 controls) were recruited from the FLOW study	Sociodemographic measures, COPD history, spirometry, DSM-IV anxiety diagnosis, HADS, spirometry, BODE index, short form-12 physical component summary, medical outcomes SF-36, Airways questionnaire, 6MWT, self-reported functional impairments, COPD exacerbations	A higher risk of anxiety is related to a COPD diagnosis and decreased health outcomes.
El-Gendry, 2015	How does an educational intervention impact practices and knowledge amongst various disease severity populations with COPD?	100 participants with COPD were recruited from a respiratory clinic in Jeddah	Dyspnea knowledge questionnaire, checklist for patients' practices, modified borg scale, HADS	Both anxiety and dyspnea can be mitigated by using strategies aimed at controlling anxiety and dyspnea.
Esser et al, 2015	Do patients with COPD have more degeneration of their cortex than age matched controls on MRI interpretation?	60 participants (30 COPD, 30 controls) were recruited from a respiratory research facility in Germany	COPD anxiety questionnaire, VBM imaging, MRI, spirometry	Individuals with COPD show decreased activation of key brain areas for the processing of fear, dyspnea, and antinociception. Those with a longer duration of COPD had more of a decrease in gray matter.
Fleehart et al, 2014	How prevalent is suicidal ideation in patients with COPD (moderate to severe)?	202 participants with COPD were recruited for a longitudinal observational study of depression	Spirometry, 6MWT, PHQ-9, HADS, structured clinical interview for depression, oxygen therapy, COPD hospitalizations, comorbidities, dyspnea, fatigue, psychiatric history	25% of these patients had depressive symptoms and 9% reported suicidal ideation. Thoughts of suicide were associated with higher levels of SOB, other mental illnesses, larger number of hospitalizations for COPD, loss of a spouse, and poor communication with their health care provider.
Frei et al, 2014	What are the comorbidities that impact health status the most in a COPD population?	408 participants with COPD were recruited from Swiss and Dutch primary care clinics	EuroQoL survey, feeling thermometer, comorbidities,	Depression, anxiety, heart disease, peripheral arterial disease, and cerebrovascular disease were the most impactful with respect to health status in patients with COPD.
Giardino et al, 2010	How is anxiety related to functional performance, quality of life and shortness of breath in a COPD population?	1828 participants with emphysema were enrolled in a national emphysema treatment trial	Demographics, Spielberger state trait anxiety inventory, Beck depression inventory, SGRQ, UCSD shortness of breath questionnaire, PFTs, 6MWT, CPET via cycle ergometry	Those with symptoms of anxiety had poorer levels of functioning with respect to quality of life, exercise capacity, and dyspnea.
Gonzalez-Guttierez et al, 2016	What is the prevalence of anxiety or depression in patients with stable COPD?	204 participants with stable COPD were recruited from an outpatient pulmonology clinic in Spain	HADS, Hamilton Anxiety Scale, spirometry, 6MWT, MRC dyspnea scale	36% of this study population had anxiety and/or depression with anxiety being more common than depression. Risk factors for anxiety and depression include younger age, higher education levels, higher BODE index, decreased home support, and a larger number of AECOPD.
Grosbois et al, 2015	Is home based management of COPD safe and effective with respect to exercise, QOL, and anxiety/depression?	211 participants with COPD were recruited from clinics in the Northern part of France	Spirometry, functional exercise test, 6 minute step test, timed up and go test, 10 second sit to stand test, HADS, visual simplified respiratory questionnaire, Maugeri respiratory failure 28 questionnaire,	A home-based PR program is safe and effective in a COPD population. This program helped to reduce levels of anxiety and depression.
Heerema-Poelman et al, 2013	One year after finishing a PR program, how many patients with COPD are still participating in an adherence exercise program?	70 participants with COPD were recruited after participating in a pulmonary rehab program in the Netherlands	Adherence to a maintenance exercise program, spirometry, incremental shuttle walk test, exercise self-efficacy, illness perception questionnaire-revised, SGRQ, HADS, duration of pulmonary rehab, number of AECOPD in 12 months, reported reasons for non-adherence	Approximately 1/3 of individuals with COPD drop out of their maintenance program during the first year. Predictors for dropout include depression, exacerbations, decreased lung function, and poorer health.

Iguchi et al, 2013	How prevalent is depression in stable COPD patients and is this associated with other risk factrs?	74 participants with COPD were recruited from hospital in Japan	Smoking history, MRC dyspnea scale, PFTs, 6MWT, BMI, BODE index, HRQOL, Center for epidemiological studies depression scale	Depression is prevalent in this COPD population and that is related to increased dyspnea, poorer HRQOL, and worse respiratory function.
Iyer et al, 2015	What is the impact of anxiety and depression on readmissions for COPD and how does this impact quality of life?	422 participants with COPD were included (132 readmissions)	Lab values, vital signs, smoking cessation counseling, pharmacotherapy prescriptions,	Both short and long term hospital readmissions are impacted by symptoms of depression. Having counselling for smoking cessation can help reduce readmission rates.
Jennings et al, 2009	How does the presence of depression impact the risk for COPD exacerbations within the coming year?	194 participants with COPD were recruited from a pulmonary rehab program	Demographics, spirometry, 6MWT, BMI, Charlson comorbidity index, medical outcomes short-form 36, Beck depression inventory, number of exacerbations of COPD	Symptoms of depression can put an individual with COPD at risk of having an acute exacerbation.
Kenealy et al, 2015	How does the use of telecare impact on quality of life and hospital admissions in COPD patients?	171 participants with COPD, heart failure, or diabetes (98 intervention and 73 controls) were recruited from 3 sites in New Zealand	Short form 36 questionnaire, HADS, self-efficacy for managing chronic disease scale, self-care of heart failure index, SGRQ, summary of diabetes self-care activities, health service use, health service cost,	The use of telecare helped patients and their families become more participatory in self-management strategies for their respective diseases. There were no significant quantitative changes associated with the use of telecare.
Kwon & Kim, 2016	What factors impact HRQOL in patients with COPD?	2734 participants with COPD were drawn from the Korean National Health and Nutrition Examination Survey	Spirometry, EuroQoL-5D, demographics, comorbidities,	There is poorer QOL in those with more severe COPD and in those with comorbid depression and osteoporosis.
Lou et al, 2012	How prevalent and frequent is anxiety and depression in a COPD population?	1100 participants with COPD were enrolled in a cross-sectional survey in China	Age, gender, education, marital status, smoking, income, weight height, HADS, spirometry, SGRQ, MRC dyspnea scale, 6MWT, BODE index,	There is an increased risk for anxiety and depression amongst COPD patients and that those who have higher levels of anxiety or depression are younger, more likely to be female, have a higher education, lower income, poorer QOL, larger smoking history, a higher BODE index, poorer 6MWD, and more dyspnea.
Lou et al, 2015	How does a community based intervention program impact health status in COPD patients?	8217 participants were recruited from a Chinese RCT	Spirometry, height, weight, BODE index, MRC dyspnea scale, 6MWT, changes in COPD knowledge, HADS	A program to improve health management knowledge can improve HADS scores and, indirectly, BODE index scores.
Mehta et al, 2014	How are psychiatric comorbidities related to quality of life and COPD severity?	59 participants with stable COPD were recruited from a pulmonary medicine department in India	Demographics, MRC dyspnea scale, COPD assessment test, HADS, insomnia severity index, SGRQ, interview for DSM-IV psychiatric diagnoses	Depression is the most common comorbid psychiatric condition amongst COPD patients. Both anxiety and depression lead to an increased risk of more severe respiratory symptoms, worse quality of life and worse insomnia.
Naberan et al, 2012	What are the differences between men and women with respect to quality of life, anxiety, and depression in a COPD population?	4574 participants (740 female) with COPD were recruited from pulmonary clinics in Spain	Spirometry, COPD symptoms, exacerbation history, self-reported physical activity, socioeconomic status, education level, COPD severity score, HRQOL, HADS	Despite women with COPD having less airway obstruction, they do have increased anxiety and depression and decreased quality of life than their male counterparts.
Omachi et al, 2009	Are people with COPD more likely to have symptoms of depression compared to those without COPD?	1504 participants (1202 COPD, 302 controls) were recruited from the function, living, outcomes and work study	Demographics, comorbidities, geriatric depression scale, airways questionnaire, short form 12 physical component summary, spirometry, 6MWT, SpO2, COPD severity score, BODE index	All individuals with COPD are at higher risk of depression, regardless of severity of obstruction. However, there is increased likelihood of experiencing depression if you have more severe COPD.
Pirraglia et al, 2011	How do changes in anxiety and depression impact how effective pulmonary rehab is in people with COPD?	81 participants with COPD were recruited from a veterans hospital in Providence	Age, gender, spirometry, beck depression inventory, beck anxiety inventory, chronic respiratory questionnaire self-reported	Participation in pulmonary rehab helps to improve quality of life and symptoms of depression but not symptoms of anxiety.

Rapsey et al, 2015	What is the lifetime prevalence of COPD with other DSM-IV diagnoses?	52095 participants were studied from population surveys across 19 countries	WHO composite international diagnostic interview, questions regarding lifetime presence of chronic conditions, smoking status	8.7% of those with COPD have major depressive disorder while 6.5% have generalized anxiety.
Raherison et al, 2014	What factors impact QOL in a COPD population?	430 participants (183 men, 247 women) with COPD were recruited from multiple centers across France	BODE index, SGRQ, HADS, motivation to quit smoking questionnaire,	Women were more likely to have both anxiety and depression than men.
Reychler et al, 2015	How does ambient music impact anxiety and perceived exertion during pulmonary rehab in patients with COPD?	41 participants with COPD were recruited from a pulmonary rehab program in Belgium	Perceived exertion, HR, SpO2, dyspnea, fatigue, anxiety (HADS), satisfaction	Being able to listen to ambient music during pulmonary rehab does not help to decrease perceived exertion but does help to negate anxiety levels.
Roberts et al, 2015	Are there adverse events associated with oxygen desaturation during 6MWT in COPD patients?	1136 participants with COPD were recruited retrospectively from a respiratory ambulatory care service in Australia	6MWT, ATS statement adverse events, pulse oximetry, SpO2, spirometry, HADS, SGRQ	It is uncommon to have adverse events during 6MWT in COPD patients. Most exertional hypoxia is not related to increased complications during submaximal exercise testing.
Schane et al, 2008	What is the prevalence of depression in a COPD population and what are the risk factors associated with this diagnosis?	18588 participants (1736 with self-reported COPD) were studied from the US Health and Retirement Survey	CES-D8 scale, comorbidities, tobacco use, alcohol use, and respiratory symptoms,	Depression is more common in COPD than in other chronic conditions and that the physical symptoms associated with COPD are related to level of depression.
Strang et al, 2014	What is the nature of anxiety experienced by COPD patients as well as the consequences of this anxiety?	31 participants with COPD were recruited from outpatient clinics in Sweden	Interviews to get qualitative descriptions of living with COPD and experiencing anxiety.	Most of the patients interviewed had experiences with anxiety in three major areas: anxiety about death, life anxiety, and things they do to help anxiety
Trappenburg et al, 2005	How can pulmonary rehab attendees with COPD be characterized by their psychological and sociodemographic variables?	81 participants with COPD were recruited from an outpatient pulmonary rehab program	PFTs, 6MWT, CPET via cycle ergometry, chronic respiratory disease questionnaire, modified pulmonary functional status and dyspnea questionnaire, HADS, psychosocial adjustment, social support list, sociodemographic variables	All patients with COPD can benefit from pulmonary rehab, regardless of prior symptoms of anxiety or depression. Levels of anxiety or depression do not mitigate the effects of rehab.
Tselebis et al, 2013	How does anxiety and depression change in COPD patients who attend pulmonary rehab?	101 participants with COPD were recruited from a pulmonary rehab program	Spirometry, Beck depression inventory, State-trait anxiety inventory	All pulmonary rehab participants have improvements in symptoms of anxiety and depression, regardless of their baseline scores.
Tsui et al, 2016	What are the psychological, physiological, and functional risk factors related to AECOPD hospitalizations?	250 participants with COPD were recruited for readmission to hospital in Hong Kong	Demographics, AECOPD admissions, oxygen therapy, comorbidities, Katz index of independence in ADLs, MRC dyspnea score, SGRQ, COPD assessment test, HADS, spirometry	There are a large number of readmissions to hospital in a COPD population and the presence of anxiety may be related to a number of avoidable readmissions.
Turan et al, 2014	How does anxiety and depression impact adherence to COPD treatment?	78 participants with COPD were recruited from a hospital in Turkey	Demographics, respiratory symptoms, spirometry, HADS, short form 36, treatment adherence, anxiety sensitivity index	Both anxiety and depression are prevalent in COPD patients and symptoms of depression are related to non-adherence to COPD medications.
von Leupoldt et al, 2011	How does anxiety and depression impact pulmonary rehab outcomes in a COPD population?	238 participants with COPD were recruited from an outpatient pulmonary rehab program in Germany	HADS, 6MWT, baseline dyspnea index, transitional dyspnea index, SF-36 (QOL)	Higher levels of dyspnea, worse QOL, and a reduced 6MWD are related to higher levels of anxiety and depression in COPD patients and that these relationships continue throughout attending a pulmonary rehab program.
Yohannes et al, 2010	What are the associations between health care utilization and management of COPD and CHF?	Review article	Descriptive data synthesis	Both anxiety and depression have an increased prevalence in those with COPD and CHR but there is no consensus on these rates. Both anxiety and depression are related to utilization of health care, quality of life, and mortality.

Yohannes et al, 2016	What are the trajectories for depression as well as the risk factors for depression in a COPD population?	1589 participants with COPD were recruited for the Evaluation of COPD Longitudinally to Identify Predictive Surrogate Endpoints study	CES-D (depression), depression patterns, 6MWT, ABGs, C-reactive protein, MRC dyspnea scale, functional assessment of chronic illness therapy-fatigue questionnaire, comorbidities, number of AECOPD	Approximately 25% of COPD patients had symptoms of depression lasting 3 years or more and that these symptoms are related to higher risk of exacerbations and poorer 6MWD.
Zhang et al, 2014	How does COPD knowledge impact presence of anxiety and/or depression, quality of life, and functional capacity in COPD patients?	364 participants with COPD were recruited from outpatient clinics in China	Spirometry, general medical information, HADS, MRC dyspnea scale, COPD assessment test, 6MWT, COPD disease knowledge	Both anxiety and depression are common in individuals with COPD and that these comorbidities are related to disease specific knowledge.

Table 1.3 – Summary of Quality of Life and COPD Studies

Authors	Research Question	Participants	Measures	Conclusions
Azargoon et al, 2016	How reliable is the COPD assessment test translated into Persian and how are the results related to PFTs?	120 participants with COPD were recruited from hospitals in Persia	Spirometry, COPD assessment test	Worse quality of life as measured by the CAT was related to increased levels of airway obstruction in this COPD population.
Benzo et al, 2016	How is the self-management assessment scale related to COPD outcomes and QOL?	292 participants with COPD were recruited from a clinic in the US	Demographics, smoking status, hospitalizations and respiratory history, LTOT, comorbidities, ADLs, PFTs, 4 meter gait speed, self-management assessment scale, chronic respiratory questionnaire, positive and negative affect schedule, MRC dyspnea scale	The ability to self-manage COPD is related to an individual's quality of life with higher levels of self-management skills being associated with better quality of life.
Berkius et al, 2013	Is HRQOL related to a stay in an intensive care unit compared to a control group?	140 participants (51 ICU COPD, 38 non-ICU COPD, 51 non-COPD controls)	EQ-5D, SF-36	HRQOL in COPD patients who have had a stay in ICU is lower than the other groups but did not further decline after being released from the ICU. HRQOL actually increased to control group levels within 2 years after ICU discharge.
Blumenthal et al, 2014	Does an intervention targeting coping skills improve quality of life in a COPD population?	326 participants with COPD were recruited from outpatient departments in American University Medical Centers	Beck depression inventory, state-trait anxiety inventory, short form-36 health survey, pulmonary quality of life scale, UCSD shortness of breath questionnaire, brief fatigue inventory, SGRQ, spirometry, 6MWT, Charlson comorbidity index, brief COPE, perceived social support scale, community health activities model program for seniors activities questionnaire, marital satisfaction inventory, caregiver strain index	A telephone coping skills targeting program helps to improve quality of life as well as functional capacity.
Bonsaksen et al, 2014	How are illness perceptions and quality of life related in individuals with COPD?	60 participants with COPD were recruited from a patient education course	Short form 12, BIPQ, physical activity, social support, general self-efficacy scale, demographics	Physical quality of life is related to consequences and identity illness perceptions while mental quality of life was related to emotional responses.
Borge et al, 2011	How prevalent is pain in COPD? What variables are different in those who experience pain and those who don't?	154 participants with COPD were recruited from clinics in Norway	PFTs, demographics, brief pain inventory, respiratory quality of life questionnaire, quality of life scale	Pain affects a large number of individuals with COPD and is related to a lower level of quality of life (disease-specific)
Borge et al, 2016	Are changes in quality of life related to changes in anxiety and depression levels in COPD?	150 participants with COPD were recruited from respiratory outpatient clinics in Norway	Sociodemographics, SGRQ, the world health organization, well-being index, HADS, PFTs	Disease specific quality of life fluctuates in parallel with other measures of well-being but not as well when compared with measures of anxiety and depression.
Bratas et al, 2010	How does a 4 week pulmonary rehab program influence psychological distress in COPD?	136 participants with COPD were recruited from rehab centers in Norway	Spirometry, SGRQ, 6MWT, HADS, sociodemographics, comorbidities	Inpatient pulmonary rehab can improve both exercise capacity, symptoms of depression, and HRQOL after 4 weeks in patients with COPD.
Cruz et al, 2016	How does a physical activity intervention improve PA levels and HRQOL in COPD patients in pulmonary rehab?	32 participants were recruited from primary care facilities	Sociodemographics, accelerometry, 6MWT, quadriceps muscle strength, SGRQ, self-efficacy scale	Using an intervention focused on physical activity behaviours both during and after attending pulmonary rehab can improve habitual physical activity levels. Those attending PR both in the intervention group and not both had improvements in HRQOL.
Dignani et al, 2016	How are sleep disorders related to quality of life in COPD patients?	102 participants with COPD were recruited from outpatient respiratory center in Italy	SGRQ, Pittsburgh sleep quality index, spirometry, MRC dyspnea scale	Quality of life worsens in COPD patients who have compromised sleep.

Ekici et al, 2015	How does having bronchiectasis, anxiety, or depression impact quality of life in COPD patients?	62 participants with COPD were recruited from a respiratory medicine department in Turkey	MRC dyspnea scale, PFTs, HADS, SGRQ, high resolution chest CT	Having bronchiectasis does not increase psychological distress or reduce HRQOL in COPD patients.
Filipowski et al, 2014	How does the quality of life and depressive symptoms impact respiratory exacerbations over a 3 year period?	233 participants (112 asthma, 121 COPD) were recruited from outpatient pulmonology clinics	PFTs, HADS, SGRQ, AQ20 questionnaire for asthma, MMSE	There are low levels of quality of life in both asthma and COPD patients and these levels drop further after being hospitalized for an exacerbation.
Gottlieb et al, 2011	How does a 7 week pulmonary rehab program for COPD patients impact HRQOL and exercise capacity?	61 participants (35 rehab, 26 control) with COPD were recruited from a pulmonary rehab program in Denmark	Spirometry, 6MWT, MRC dyspnea scale, SGRQ	Pulmonary rehab improves walking distance but these improvements are difficult to maintain. There was no significant improvement in HRQOL with pulmonary rehab participation.
Holm et al, 2014	How does age impact anxiety, depression, quality of life and breathlessness in a COPD population?	468 participants with COPD were recruited from Alpha-1 Antitrypsin research registry	Demographics, HADS, SGRQ, MRC dyspnea scale	A younger age was associated with increased symptoms with respect to depression, quality of life and SOB than those of an older age.
Irwin et al, 2015	How valid is the PROMIS scale in both stable and recently exacerbated COPD patients?	185 participants (100 stable, 85 exacerbation) with COPD were recruited from outpatient clinics and hospitals in the US	Patient-reported outcomes measurement information system, spirometry, 6MWT, demographics, SGRQ, MRC dyspnea scale, Pittsburgh sleep quality index, functional assessment of chronic illness therapy, exacerbations of chronic pulmonary disease tool	This study found the PROMIS measure to be valid in both stable and exacerbated COPD populations. Patients with stable COPD have better quality of life than those in an exacerbation.
Jackson et al, 2014	How is self-efficacy in COPD related to functional capacity and quality of life?	325 participants with COPD were recruited from primary care facilities in Texas	COPD self-efficacy scale, 6MWT, short-form health survey, chronic respiratory questionnaire	COPD self-efficacy is related to both 6MWD and HRQOL in a COPD population.
Jacobsen et al, 2012	How does exercise training change shortness of breath and quality of life in COPD patients? How does this change based on COPD severity?	143 participants with COPD were recruited from a pulmonary rehab program with 108 participants remaining after the PR program	Demographics, spirometry, BMI, senior fitness test, MRC dyspnea scale, clinical COPD questionnaire, short form-36	Dyspnea can help to predict quality of life in a COPD population. Exercise training did not change HRQOL in this study.
Janssens et al, 2011	Do fears associated with dyspnea relate to COPD outcomes?	73 participants with COPD were recruited from a pulmonary rehab program in Belgium	Spirometry, CPET on cycle ergometer, 6MWT, isometric quadriceps force, inspiratory muscle strength, chronic respiratory disease questionnaire, pulmonary functional status and dyspnea questionnaire, HADS, breathlessness beliefs questionnaire	Higher dyspnea ratings during exercise testing are related to higher levels of anxiety as well as fear related to shortness of breath. Both dyspnea related fear and anxiety level are related to lower quality of life.
Jones et al, 2011	How does COPD impact HRQOL as measured by multiple questionnaires?	1817 participants with COPD were recruited from 7 European Countries	Demographics, SGRQ, short form-12, functional assessment of chronic illness therapy fatigue scale	There are impairments in QOL across all severity stages of COPD but also can be wide variation within each GOLD stage
Kanervisto et al, 2010	How does COPD impact quality of life compared to the general population?	4718 participants (COPD 277, chronic bronchitis, 630, control, 3817) were selected from a Finnish health examination survey	Demographics, ADLs, spirometry, HRQOL	Women with COPD had worse QOL than men. Chronic bronchitis patients had worse ADLs and exercise than the general population
Kim et al, 2014	What is the quality of life in Korean individuals with COPD and how does this change based on COPD severity?	200 participants with COPD were recruited from respiratory outpatient clinics in Korea	EQ-5D, clinical COPD questionnaire, spirometry, demographics, breathlessness	Breathlessness is more related to HRQOL than COPD severity.
Kim & Kim, 2014	To determine interventions that are gender specific in order to improve HRQOL in COPD patients.	751 participants (556 male, 195 female) with COPD were recruited in the KNHANES study in Korea	HRQOL, age, education, socioeconomic status, marital status, COPD severity, comorbidities, smoking status, self-reported PA	Females with COPD have higher HRQOL than their male counterparts. Both men and women's HRQOL was impacted by physical activity level.

Labreque et al, 2011	How well does a self-management intervention work on improving HRQOL in a COPD population?	57 participants with stable COPD were recruited from outpatient departments in Quebec	SGRQ, COPD knowledge questionnaire, COPD exacerbations	An education program focused on COPD management is helpful for increasing HRQOL and decreasing COPD health care utilization.
Lin et al, 2014	What areas of HRQOL are impacted by severity of airway obstruction in COPD?	670 participants with COPD were recruited from a multi-center study in 7 US medical centers	Spirometry, 6MWT, MRC dyspnea scale, functional assessment of chronic illness therapy dyspnea scale, EQ-5D, patient reported outcomes measurement information system	Both the EQ-5D and the PROMIS scales are useful in measuring quality of life in a COPD population. Social participation and physical abilities are decreased in those with more significant airway obstruction.
Maric et al, 2016	What is the difference in QOL between end-stage COPD patients and advanced lung cancer patients?	200 participants (100 COPD, 100 lung cancer) were recruited from both outpatient and inpatient clinics in Serbia	Medical outcomes short form health survey, physical component summary, EORTC-QLQ-C30 (QOL measure), SGRQ, Beck depression inventory	HRQOL is similar in both advanced lung cancer patients and end-stage COPD patients.
Mehta et al, 2014	How are psychiatric comorbidities related to quality of life and COPD severity?	59 participants with stable COPD were recruited from a pulmonary medicine department in India	Demographics, MRC dyspnea scale, COPD assessment test, HADS, insomnia severity index, SGRQ, interview for DSM-IV psychiatric diagnosis	Depression is the most common comorbid psychiatric condition amongst COPD patients. Both anxiety and depression lead to an increased risk of more severe respiratory symptoms, worse qualityof life and worse insomnia.
Mkacher et al, 2016	How does including balance training in pulmonary rehab impact QOL, anxiety, and depression in a COPD population?	62 participants (32 intervention, 30 control) with COPD were recruited from a PR program in Tunisia	Multidimensional fatigue inventory, SGRQ, HADS, demographics, PFTs, 6MWT	The addition of balance training to a pulmonary rehab program can help to improve quality of life, anxiety and depression over and above the improvements a COPD patient gets with PR alone.
Moy et al, 2016	How efficacious is the taking healthy steps program on improving PA and QOL after 12 months?	239 participants (154 treatment, 84 control), with stable COPD were recruited from a veterans database in the US	MRC dyspnea scale, SGRQ, pedometry	There is an initial improvement in step counts after 4 months of internet based intervention but this is not maintained at 12 months.
Naberan et al, 2012	What are the differences between men and women with respect to quality of life, anxiety, and depression in a COPD population?	4574 participants (740 female) with COPD were recruited from pulmonary clinics in Spain	Age, gender, smoking status height, weight, spirometry, COPD symptoms, exacerbation history, self-reported physical activity, socioeconomic status, education level, COPD severity score, HRQOL, HADS	Despite women with COPD having less airway obstruction, they do have increased anxiety and depression and decreased quality of life compared to their male counterparts.
Negi et al, 2014	What are the predictors of QOL in COPD patients in India?	126 participants with COPD were recruited	SGRQ, demographics, smoking status, PFTs, MRC dyspnea scale, patient health questionnaire-9	HRQOL was impaired in this COPD population and the degree of impairment was related to the severity of airway obstruction. The following were found to be related to HRQOL: depression, FEV1, MI, and dyspnea.
Ninot et al, 2011	How does a program for self-management change quality of life and functional exercise capacity in a COPD population?	45 participants with COPD (22 usual care, 23 intervention group) were recruited from a hospital in France	6MWT, SGRQ, health status questionnaire, CPET on a cycle ergometer, self-reported daily PA, health care utilization, PFTs	The use of a self-management intervention improved exercise capacity, reduced health care costs, and improved HRQOL
Oancea et al, 2015	How does an educational program focused on COPD impact AECOPDs requiring ED visits or hospitalizations?	76 participants with stable COPD were recruited	Spirometry, SGRQ	COPD education is related to a lower number of AECOPD and improved quality of life.
Papadopoulos et al, 2011	How valid is the Greek version of the clinical COPD questionnaire in a COPD population as well as a healthy control?	143 participants (93 with COPD) were recruited from outpatient departments in Athens	PFTs, short form health survey, clinical COPD questionnaire	The CCQ had been found to be valid in the Greek language. Higher scores for HRQOL were related to smoking cessation in this population.

Park & Larson, 2015	Describe cognitive processing in COPD patients and how this impacts HRQOL in COPD patients?	593 participants with COPD were selected from the National Emphyema Treatment Trial in the US	PFTs, demographics, clinical data, University of California San Diego Shortness of Breath Questionnaire, Beck depression inventory, vitality subscale of the medical outcomes study 36 item short form health survey, 6MWT, CPET on cycle ergometer, trail making test, SGRQ	While individuals with COPD perform poorly on the trail making test, this is not significantly related to PFTs. It is related to HRQOL.
Popa-Velea & Purcarea, 2014	How does self-efficacy relate to HRQOL as well as airway obstruction in COPD patients?	54 participants with COPD were recruited from hospitals in Bucharest	COPD self-efficacy scale, life orientation test, quality of well-being scale, functional impairment scale, spirometry	Level of optimism and self-efficacy were both related to HRQOL in a COPD population.
Raherison et al, 2014	What factors impact QOL in a COPD population?	430 participants (183 men, 247 women) with COPD were recruited from multiple centers across France	BODE index, SGRQ, HADS, motivation to quit smoking questionnaire	Women were more likely to have both anxiety and depression than men.
Rodriguez-Rodriguez et al, 2013	How prevalent is disability in the areas of ADLs, IADLs, and mobility in individuals with COPD?	13624 participants (981with COPD) were identified from a larger study (European Health Interview Survey for Spain)	Functional disability in the areas of ADLs, IADLs, and mobility measured by survey questions, sociodemographics, self-perceived health, presence of depression, comorbidities, BMI, exercise level	Disability is more prevalent in the COPD population when compared to the general population. Having poor self-reported health, depression, or anxiety are related to increased disability levels.
Roman et al, 2013	How does a pulmonary rehab program with or without follow maintenance impact quality of life in those with COPD?	97 participants with COPD were recruited from primary care practices in Spain	Chronic respiratory questionnaire, PFTs, 6MWT, number of AECOPD, demographics, MRC dyspnea scale	The use of a follow-up maintenance program after a 3 month pulmonary rehab program does not improve quality of life in COPD.
Trappenburg et al, 2005	How can pulmonary rehab attendees with COPD be characterized by their psychological and sociodemographic variables?	81 participants with COPD were recruited from an outpatient pulmonary rehab program	PFTs, 6MWT, CPET via cycle ergometry, chronic respiratory disease questionnaire, modified pulmonary functional status and dyspnea questionnaire, HADS, psychosocial adjustment, social support list, sociodemographics	All patients with COPD can benefit from pulmonary rehab, regardless of prior symptoms of anxiety of depression. Levels of anxiety of depression do not mitigate the effects of rehab.
Voll-Aanerud et al, 2010	How does HRQOL interact with respiratory symptoms in those with COPD compared to controls?	6302 participants (336 COPD, 598 asthma, 5368 controls) were studied from data from the European Community Respiratory Health Survey	Respiratory symptoms, smoking status, demographics, short form-36, spirometry	General respiratory symptoms are related to lower quality of life in all of the population, regardless of whether an individual has a diagnosis of asthma or COPD.
Wright et al, 2015	Does a pharmacy service delivery program (community based) provide effective service to a COPD population?	306 participants with COPD signed up for this service at their UK pharmacy	Demographics, EQ-5D (quality of life), adherence assessment, GP visits for COPD, AECOPD, hospital admissions, ED visits, rescue medications obtained from the pharmacy, sick days off work	Medication adherence was improved with this intervention as well as improved quality of life and a smaller number of visits to their family doctor for COPD related issues.
Wu et al, 2015	How does quality of life in COPD patients impact medical costs in China?	687 participants with COPD were recruited in 4 Chinese cities	EQ-5D (quality of life), medical costs obtained from subjects medical charts	Worse quality of life was related to COPD severity, older age, and increased medical costs related to COPD.
Xiang et al, 2015	What are the correlates for QOL in COPD patients in China?	142 participants with COPD were recruited from hospitals in Hong Kong while being hospitalized for an AECOPD	Spirometry, number of hospital admissions, life event scale, MMSE, Medical Outcomes study short form 12, SGRQ	Having COPD along with symptoms of depression can decrease quality of life.

Table 1.4 – Summary of Illness Perceptions and COPD Studies

Authors	Research Question	Participants	Measures	Conclusions
Bonsaksen et al, 2014	How does HRQOL related to illness perceptions, self-efficacy, PA, and social support in a COPD population?	60 participants with COPD were recruited from a patient education course in Norway	Short form-12 (HRQOL), BIPQ, self-report physical activity, social support, general self-efficacy scale, sociodemographics	Physical quality of life was related to the consequence and identity subscales of the BIPQ and mental quality of life was related to emotional illness perceptions.
Bonsaksen et al, 2015	What are the factors related to self-esteem in individuals with COPD and those with morbid obesity?	223 (89 COPD, 134 obese) participants were recruited from patient education courses in Norway	Sociodemographics, Rosenberg self-esteem scale, general self-efficacy scale, BIPQ, social support, , employment status, self-reported physical activity	Self-esteem and self-efficacy are closely related in both study populations. The belief that you can cope with your disease is important with respect to self-esteem in both study populations.
Borge et al, 2014	Is breathlessness related to more negative illness perceptions in a COPD population?	154 participants with COPD were recruited from a hospital in Norway	Respiratory quality of life questionnaire, short form 12 (HRQOL), global quality of life scale, spirometry	The perception that COPD is more threatening is related to increased levels of dyspnea in this population.
Bos-Touwen et al, 2015	What variables help to promote self-management in various chronic disease patients?	1154 participants (422 DM, 290 COPD, 223 CHF, 219 CRF) were recruited from outpatient clinics in the Netherlands	Patient activation measure, short form 12 health survey, HADS, BIPQ, multidimensional scale of perceived social support, sociodemographics, disease characteristics, Charlson comorbidity index	All of the chronic diseases included in this study had their patients score low on patient activation for self-management. More negative illness perceptions are one of the variables that are related to poor self-management.
Braido et al, 2011	How prevalent is disability in a COPD population and which of the following variables may also be related to disability: illness perceptions, shortness of breath, quality of life, stress?	164 participants with COPD were recruited from clinic visits to a respiratory department in Genoa	Illness perception questionnaire, psychological general well-being index, profile of mood states, short form 36, Barthel disability index, Lawton instrumental activities of daily living scale, MRC dyspnea scale, Charlson comorbidity index	Disability can occur at any stage of COPD and is most closely related to level of dyspnea. Level of disability can impact an individual's illness perceptions as well.
Braido et al, 2015	How prevalent is disability in a COPD population and how is it related to COPD severity, illness perceptions, health status, and risk of death?	694 participants with COPD were recruited from clinics in Italy	Barthel activities of daily living index, Lawton instrumental ADL scale, Charlson comorbidity index, MRC dyspnea scale, Illness perception questionnaire, psychological general well-being index, short form 12 health survey	Dyspnea was found to have the strongest relationship with disability in a COPD population. Being disabled also impacts illness perceptions in a negative way, which could worsen quality of life.
Dowson et al, 2004	How is self-management impacted by anxiety, depression, illness perceptions, and alcohol use in COPD patients?	39 participants with COPD were recruited from a non-acute hospital ward in New Zealand	COPD self-management interview, DSM-IV for psychiatric comorbidities, Likert type questions for illness perceptions	Poor self-management skills are related to the presence of depression, current or old alcohol dependence, and those with negative illness perceptions.
Fischer et al, 2010	Are COPD patients' illness perceptions related to time since diagnosis?	87 participants with COPD were recruited from a pulmonary rehab program in Rotterdam	Sociodemographics, illness perception questionnaire, PFTs, 6MWT, dyspnea, chronic respiratory questionnaire	Over time, an individual with COPD starts to be less optimistic and feel that their disease is more serious and less controllable.
Hartman et al, 2013	Determine the level of physical activity in those with COPD as well as the amount of time pent sitting. Also assess the factors associated with PA.	115 participants were recruited from outpatient clinics in the Netherlands	Accerometry, spirometry, MRC dyspnea scale, incremental cycle ergometer exercise test, 30 second sit to stand test, fat free mas, BODE index, social support, depression, illness perceptions, self-efficacy, sleep quality, QOL	There are lower levels of PA the more severe the airway obstruction is. Sitting time was not dependent on COPD severity.
Hoth et al, 2011	What are the causes that individuals with COPD and a significant smoking history attribute their disease to?	394 participants with COPD were recruited from 2 medical centers in Denver, Colorado	Sociodemographics, illness perception questionnaire, health behaviors and symptoms assessed via questionnaire	Patients with COPD attributed their disease to smoking, pollution, heredity, and personal behaviours. Psychological attributions for COPD were related to higher levels of anxiety, depression, and worse HRQOL.

Howard et al, 2009	How are illness perceptions and panic related in patients with COPD?	59 participants with COPD were recruited from a cardiothoracic center in the UK	Illness perception questionnaire, HADS, panic disorder severity scale, sociodemographics, SGRQ, spirometry	Beliefs regarding timeline, emotional representations, illness identity, and disease consequences were related to whether an individual was a panicker or a non-panicker.
Hyphantis et al, 2014	How are physical symptoms related to illness perceptions in people with COPD, diabetes, and rheumatic diseases?	303 participants (171 DM, 50 COPD, 43 rheumatic, 39 combination) were recruited from emergency departments in Greece	Patient health questionnaire, symptom distress checklist, world health organization quality of life instrument, mini international neuropsychiatric interview, patient health questionnaire-9, general comorbidity scale, BIPQ	Scores on the patient health questionnaire were related to personal beliefs about COPD and their perception of the success of their treatment.
Hyphantis et al, 2015	How prevalent is major depressive disorder amongst patients with long-term conditions?	349 participants (194 diabetes, 56 COPD, 49 rheumatic disease, 50 with 2 or more conditions)	Patient health questionnaire-9, mini international neuropsychiatric interview, symptom distress checklist, world health organization quality of life instrument, BIPQ	27.2% of these participants had major depressive disorder. Having depression was related to decreased levels of personal and treatment control, increased emotional representations, and a larger number of disease concerns.
Korpershoek et al, 2016	Activation for self-management is related to which variables in a COPD population?	290 participants were recruited from 3 medical settings in the Netherlands	Spirometry, patient activation measure, short form-12 health survey, HADS, BIPQ, Multidimensional scale of perceived social support, sociodemographics, comorbidities	Very few patients with COPD are concerned with self-management strategies. The things associated with a decreased activation are: negative illness perceptions, anxiety, worse airway obstruction, higher BMI, older age, and fewer comorbidities.
Mewes et al, 2016	How do psychological factors impact both disability and quality of life in a COPD population?	502 participants with COPD were recruited from patient support group websites in Germany	Short form health survey, SGRQ, chronic respiratory questionnaire, 36 item short form health survey, COPD assessment test, patient health questionnaire, comorbidities, BIPQ, causal illness attributions	A lower level of disability is related to more positive illness perceptions, improved mental health, and a stronger sense of internal control.
Ninou et al, 2016	Are illness perceptions related to ED visits in individuals with chronic conditions?	304 participants (171 DM, 50 COPD, 43, rheumatic disease, 39 combination) were recruited from the Greek health system	Demographics, MRC dyspnea scale, health assessment questionnaire, ABG, blood glucose, mini international neuropsychiatric interview, patient health questionnaire-15, comorbidities, BIPQ, number of ED visits	The perception of illness comprehensibility is related to ED visits in patients with all chronic conditions studied. Other variables related to ED visits include younger age, number of comorbidities, and worse disease symptoms.
Scharloo et al, 1998	Are illness perceptions and coping strategies related to physical and social functioning in 3 chronic disease populations?	244 participants (80 COPD, 80 psoriasis, 84 RA) were recruited from outpatient clinics in Leiden University Medical Center	Structured interview on illness perceptions, illness perception questionnaire, utechtse coping list, daily activities of life questionnaire, psoriasis disability index, health assessment questionnaire, medical outcomes study short form general health survey, spirometry	Worse functioning in the areas of general role and social functioning are related to a more chronic illness duration belief, increased disease consequences, more passive coping, and a stronger identity for the illness.
Scharloo et al, 2000	How is coping strategies combined with illness perceptions impacting disability in COPD patients?	86 participants were recruited from outpatient respiratory clinics in the Netherlands	Spirometry, illness perception questionnaire, Utrecht coping list, functional status, number of hospital visits	Coping style and illness perceptions are related to social functioning, hospital visits, mental health, and perceptions of health.
Scharloo et al, 2007	How are illness perceptions and quality of life related in COPD patients?	171 participants with COPD were recruited from several medical centers in the Netherlands	Illness perception questionnaire, PFTs, MRC dyspnea scale, SF-36, quality of life for respiratory illness questionnaire,	Higher quality of life was related to having a decreased attention to disease symptoms, weaker emotional reactions to their COPD, and more positive beliefs about how their COPD will impact them.
Stehr et al, 1991	Which physiological and psychosocial variables are related to AECOPD?	33 particpants with COPD were recruited from a veterans hospital in Albuquerque	ED visits, PFTs, interviews to elicit illness representations	Exacerbations of COPD were related to negative beliefs about prognosis, death of a close relative, and a higher FVC in this study population.

Tiemensma et al, 2016	How are illness perceptions, coping style, and quality of life related in a COPD population?	100 participants with COPD were recruited through a pharmacy database in California	BIPQ, Utrecht proactive coping competency scale, self-rated quality of life, sociodemographics	The COPD patients in this study group had good coping skills but slightly more negative illness perceptions than people with other respiratory diagnoses. There was relatively low concern about their illness, feelings of low treatment control as well as a large number of identified physical symptoms.
Vaske et al, 2016	How do illness representations impact coping strategies in individuals with COPD?	444 participants with COPD were recruited to complete online questionnaires	Demographics, BIPQ, Essener coping questionnaire, short form-12 (HRQOL)	Illness perceptions along with coping strategies can be used to predict HRQOL in COPD.
Weldam et al, 2013	How are daily activities and HRQOL impacted by illness perceptions, depression, and coping strategies in patients with COPD?	90 participants with COPD were recruited to complete questionnaires	BIPQ, Utrecht proactive coping competence questionnaire, Centers for epidemiologic studies depression scale, MRC dyspnea scale, clinical COPD questionnaire, functional performance inventory	Higher levels of HRQOL are related to fewer depressive symptoms and more positive COPD illness perceptions.
Weldam et al, 2014	Which specific illness perception dimensions impact HRQOL in COPD?	90 participants with COPD were recruited to complete questionnaires throughout the Netherlands	Spirometry, BIPQ, MRC dyspnea scale, clinical COPD questionnaire, chronic respiratory disease questionnaire	Both dyspnea and illness perceptions can impact HRQOL. Better HRQOL is related to having a good understanding of COPD, have fewer emotions related to the disease, feel like they have better treatment control, and have a lower impact on their daily lives from their disease.
Zoeckler et al, 2014	How does addressing illness representations prior to participating in a pulmonary rehab program change the outcomes after the program in COPD patients?	96 participants with COPD were recruited from a pulmonary rehab program in Germany	Illness perception questionnaire, short form 36 health survey, HADS, COPD specific anxiety questionnaire, PFTs, 6MWT	Illness representations measured prior to participating in pulmonary rehab can be used to predict both psychological well-being and exercise capacity after pulmonary rehab.

Chapter 2 - Illness Perceptions, Anxiety, Depression and Their Impact on the Outcomes of Pulmonary Rehabilitation in those with Chronic Obstructive Pulmonary Disease

2.1 Abstract

Background - COPD is known to be associated with anxiety, depression, and reduced levels of physical activity. Pulmonary rehabilitation has been shown to improve all of these outcomes in this population.

Objectives – The aim of this study was to determine the ways in which anxiety, depression, and/or negative illness perceptions affect key outcomes in pulmonary rehabilitation (habitual physical activity, health related quality of life, and submaximal exercise capacity) compared to those with lower levels of anxiety, depression, and negative illness perceptions.

Methods – New participants from the Saskatoon Pulmonary Rehabilitation program with a spirometry confirmed diagnosis of COPD were approached to participate in this study. Anxiety and depression were measured with the Hospital Anxiety and Depression Scale (HADS), health related quality of life (HRQoL) was measured with the St. George's respiratory questionnaire (SGRQ), dyspnea via the MRC dyspnea scale, illness perceptions via the Brief Illness Perceptions Questionnaire (BIPQ), typical physical activity by the Modified Baecke Questionnaire for Older Adults (MBQOA), weekly actual physical activity by self-report activity tracker, and one third of the participants (n=6) used an accelerometer to measure physical activity. These measures were taken again after 3 months.

Results – Sixteen participants were recruited and ten of these dropped out of pulmonary rehabilitation prior to their 3-month follow-up, therefore, follow-up data was not analyzed. Increased anxiety was correlated with poorer HRQoL and higher MRC dyspnea score while higher levels of depression were correlated with higher dyspnea on exertion and MRC dyspnea score, poorer HRQoL, and more negative illness perceptions. Worse illness perceptions were correlated with worse HRQoL. Higher levels of self-reported physical activity were correlated with lower MRC scores.

Conclusions – We were unable to determine if individuals in pulmonary rehabilitation who have anxiety, depression, and/or negative illness perceptions have reduced improvements in outcomes

of the program due to dropouts and low numbers. Anxiety, depression, and negative illness perceptions are associated with worse HRQoL and increased levels of dyspnea.

2.2 Introduction

Chronic obstructive pulmonary disease (COPD) is a lung condition affecting an estimated 2.6 million Canadians (17%) between the ages of 35 and 79 years (Evans et al, 2014), with only 817,894 of those individuals being diagnosed by a physician (Statistics Canada, 2016). COPD is the fourth leading cause of death in Canada (O'Donnell et al, 2008) and has become the third leading cause of death in the United States (Minino, Jiaquan, & Kochanek, 2010). COPD is a broad term encompassing both chronic bronchitis and emphysema. It is characterized by progressive, partially reversible airway obstruction, and is typically caused by smoking (O'Donnell et al, 2008). Its most recognizable symptom is shortness of breath on exertion, progressively worsening as the disease progresses (O'Donnell et al, 2014).

Pulmonary rehabilitation (PR) is a widely recommended treatment for COPD. It is typically made up of a structured exercise program, incorporating mostly endurance activities, such as walking, but also some strengthening and flexibility activities. Some PR programs also include education sessions on topics such as dealing with symptoms, exercising at home, medications, and more. This type of intervention has been shown to be successful in increasing quality of life (Mukundu et al, 2015), exercise time (Miki et al, 2017), and improving symptoms of anxiety and depression (Tselebis et al, 2013; Coventry, 2009).

Individuals with COPD are more likely to experience symptoms of depression and anxiety (Janssen et al, 2010), with symptoms of depression being associated with an increase in mortality (de Voogd et al, 2009). There is a prevalence of 9% (Rapsey et al, 2015) to 33% (Bratek et al, 2015) of people with COPD have symptoms of depression and 6% (Rapsey et al, 2015) to 42% (Bratek et al, 2015) have symptoms of anxiety. Both depression (Jennings et al, 2009) and anxiety (Eisner et al, 2010) are associated with increased risk of acute exacerbations of COPD. Anxiety and depression negatively impact the prognosis in an individual with COPD through increased risk of acute exacerbations and death, and conversely, having COPD increases the risk of developing depression (Atlantis et al, 2013). It has been shown that pulmonary rehabilitation programs can improve both depression and anxiety in individuals with COPD (Tselebis et al, 2013; Coventry, 2009). Both depression (Spruit et al, 2015) and anxiety (Eisner et al, 2010; Giardino et al, 2010) have been shown to have a negative impact on submaximal exercise performance in individuals with COPD. It has been demonstrated that symptoms of depression and anxiety impair improvements in exercise capacity in pulmonary rehabilitation (von Leupoldt et al, 2011).

Illness perceptions are a product of the common-sense model of illness representations. This self-regulatory model has several components to illness representations – identity, causality, timeline, and consequences (Baumann et al, 1989). As individuals progress through their illness, their perceptions of their condition will be shaped and eventually reshaped according to whether they have had success or failure with various coping mechanisms and management techniques (Leventhal et al, 2011). These perceptions are integrated with a person's pre-existing illness schemata to influence coping style and illness management (Hale et al, 2007). Because these beliefs are fluid and change based on experience, coping mechanisms and disease management can be modified when illness perceptions change. Illness perceptions have been shown to impact quality of life (QOL) in patients with COPD (Scharloo et al, 2007). There is evidence that assessing illness perceptions in individuals with COPD, along with discussing and changing negative perceptions will help to decrease levels of disability and improve QOL (Kaptein et al, 2008). To date, the interrelationship between illness perceptions, anxiety, depression, and pulmonary rehabilitation outcomes (QOL, physical endurance) has not been reported.

The primary research question was: Among participants in a pulmonary rehabilitation program, are the changes in health related quality of life, submaximal exercise capacity, and habitual physical activity different between those with anxiety, depression, and negative illness perceptions compared to those without the aforementioned conditions?

Secondary questions are as follows:

1) Are negative illness perceptions associated with a higher level of depression and/or anxiety in individuals with COPD?

2) What is the relationship between dyspnea levels as well as illness severity and anxiety, depression, and illness perceptions?

2.3 Methods

Subjects were recruited through the local pulmonary rehabilitation program. Inclusion criteria were: a diagnosis of COPD ($FEV_1/FVC < 0.70$), be enrolled/re-enrolled in (after a >6-month hiatus) and within their first six weeks of starting the pulmonary rehab program, be able to provide informed consent, and be able to read and speak English. Exclusion criteria included history of treatment for a psychiatric disorder, history of dementia, and the presence of a significant cardiac, metabolic, or other medical condition or musculoskeletal dysfunction that would significantly limit their exercise tolerance. This study was approved by the local Biomedical Research Ethics Board and received operational approval through the local Health Region. All of the study participants signed an informed consent document at their initial visit.

The following variables were measured in each participant: i) anxiety and depression levels with the Hospital Anxiety and Depression Scale (HADS) (Zigmond & Snaith, 1983), ii) health related quality of life (HRQoL) by the St. George's Respiratory Questionnaire (SGRQ) (Jones et al, 1992), iii) shortness of breath by the Medical Research Council (MRC) Dyspnea Scale (Fletcher et al, 1959), iv) illness perceptions by the Brief Illness Perception Questionnaire (BIPQ) (Broadbent et al, 2006), and v) typical physical activity levels by the Modified Baecke Questionnaire for Older Adults (MBQOA) (Voorips et al, 1991). All questionnaires have been validated for use in a COPD population. Weekly habitual physical activity was also measured in each participant through the use of a weekly activity tracker where they recorded the time they completed the activity, what the activity was, the duration, and how short of breath they were on a 0-10 scale. In addition to the activity tracker, one third of the participants wore an ActiGraph GT3X tri-axial accelerometer to record their physical activity for the week. This was due to the total number of accelerometers available in the research study. All measures were completed at the initial visit, and again, after three months of participation in the PR program.

As part of participating in the PR program, each participant undergoes cardiopulmonary exercise testing (CPET), spirometry, six-minute walk test, and medical screening. PR staff reassess six-minute walk distance after three months of participation in the program to track their progress. Exertional dyspnea score (0-10) was recorded throughout the 6MWT to give a peak dyspnea level. The results of all of these tests, excluding the CPET, were made available to study staff for purposes of this study. After their initial assessment by PR staff, participants attended the PR program three times per week, which includes 30 minutes of structured stretching and strengthening exercises, and 30 minutes of walking, biking, rowing, or stepping, all of which are supervised by the PR staff. Along with exercise, participants also had the option of attending educational sessions on a variety of topics offered by the PR program.

2.3.1 – Analysis

In order to achieve statistical power of 80% with an alpha of 0.05 it was calculated with an online power calculator (Kane, 2017) based on previous research on the HADS in a COPD population (Bratas et al, 2014) that the required sample size for this research project was 485. An analysis of variance was intended to be performed in order to compare groups with higher levels of anxiety/depression/negative illness perceptions with those who scored on the opposite ends of the spectrum. This was not completed secondary to high levels of program drop-out. Paired t-tests were performed on all of the variables to determine any differences in the variables from baseline to three-month follow-up in those who completed the follow-up measures. Spearman correlations were completed looking at all independent variables and their relationship with the dependent variables for the baseline values only. Statistical significance was set at $p<0.05$. SPSS software version 20 (IBM Corp, 2011) was used for all statistical analyses.

2.4 Results

Sixteen participants were recruited for this study over the course of one year (10 male, 6 female), with a mean age of 66 ± 6.7. See Table 2.1 for baseline characteristics. With 16 participants, this research project achieved 27% power. They had an average FEV_1/FVC of 52% ± 16.9, giving them an average severity of moderate according to the Canadian Thoracic Society guidelines (O'Donnell et al, 2008). Ten of the study participants dropped out of the PR program prior to their three-month follow-up sessions. Their reasons for dropping out of the program were not recorded. There were insufficient numbers from follow-up data to run any statistical analyses comparing baseline to follow-up values.

Table 2.1 – Baseline Characteristics of Pulmonary Rehabilitation Participants

Variable	**Mean ± standard deviation**
Age (years)	66±6.7
Height (cm)	170.81 ± 9.62
Weight (kg)	84.52 ± 22.08
FEV_1 (% predicted)	51.56 ± 16.23
FEV_1/FVC (%)	51.78±16.9
6MWD (m)	374.21±99.96
Peak SOB with 6MWT (0-10)	3.46±1.47
SGRQ symptoms	49.71±19.71
SGRQ activity	60.62±22.93
SGRQ impacts	29.25±17.45
SGRQ total	42.18±17.15
Anxiety (/21)	7.13±3.76
Depression (/21)	5.88±3.83
MRC dyspnea score (/5)	3±0.89
BIPQ score (/80)	43.31±12.80
BIPQ consequences (/10)	5.81 ± 2.83
BIPQ timeline (/10)	9.81 ± 0.54
BIPQ personal control (/10)	5.63 ± 2.63
BIPQ treatment control (/10)	7.31 ± 1.89
BIPQ identity (/10)	5.44 ± 2.68
BIPQ illness concern (/10)	7.31 ± 3.16
BIPQ coherence (/10)	6.81 ± 2.69
BIPQ emotional representation (/10)	4.56 ± 3.16
Baecke score	21±5.33
Average daily PA (min)	111.74 ± 94.36
Average SOB during daily PA (0-10)	2.07 ± 1.06
% time spent sedentary	84.44 ± 6.56
% time spent in light	11.15 ±5.99
% time spent in lifestyle	3.36 ± 2.09
% time spent in moderate	1.01 ±0.64
% time spent in vigorous	0.02 ± 0.05

For the individuals who completed both sets of questionnaires, there was no significant difference between their baseline and follow-up variables (p<0.05). There were several significant (p<0.05) correlations that were found regarding this study at baseline. Level of anxiety was significantly correlated with higher scores on SGRQ impacts, total SGRQ score, MRC dyspnea score, and BIPD score. Higher levels of depression were significantly correlated with higher peak dyspnea during 6MWT, higher scores for SGRQ activity and impacts subscales, as well as total SGRQ, higher MRC dyspnea score, and higher overall BIPQ score. Higher illness perception scores were significantly correlated with higher SGRQ impacts. Daily physical activity as measured by self-reported activity tracker had no significant correlations. See Table 2.2 for details on correlations.

Table 2.2 – Correlations Between Anxiety, Depression, and Illness Perceptions with Study Outcomes

Variables	**N**	**Spearman Correlation**	***p***
Anxiety with Age	16	-0.095	0.758
Anxiety with FEV_1 (%)	16	-0.012	0.977
Anxiety with FVC (%)	16	0.380	0.314
Anxiety with FEV_1/FVC	16	0.000	1.000
Anxiety with 6MWD	16	-0.536	0.059
Anxiety with peak 6MWT SOB	**16**	**0.636**	**0.019**
Anxiety with SGRQ Symptoms	16	0.183	0.498
Anxiety with SGRQ Activity	16	0.451	0.080
Anxiety with SGRQ Impacts	**16**	**0.623**	**0.010**
Anxiety with Total SGRQ	**16**	**0.512**	**0.043**
Anxiety with MRC dyspnea score	**16**	**0.663**	**0.005**
Anxiety with depression	**16**	**0.785**	**0.000**
Anxiety with BIPQ Consequences	16	0.459	0.074
Anxiety with BIPQ Timeline	16	0.102	0.708
Anxiety with BIPQ Personal Control	16	0.053	0.846
Anxiety with BIPQ Treatment Control	16	0.097	0.720
Anxiety with BIPQ Identity	16	0.393	0.132
Anxiety with BIPQ illness concern	**16**	**0.572**	**0.021**
Anxiety with BIPQ Coherence	16	-0.050	0.855
Anxiety with BIPQ emotional representation	**16**	**0.631**	**0.009**
Anxiety with overall BIPQ score	**16**	**0.558**	**0.025**
Anxiety with Total Baecke	16	-0.066	0.814
Anxiety with average SOB with Activity	16	0.111	0.812
Depression with Age	16	0.028	0.931
Depression with FEV_1 (%)	16	0.036	0.933
Depression with FVC (%)	16	0.160	0.682
Depression with FEV_1/FVC	16	0.101	0.796
Depression with 6MWD	16	-0.436	0.137
Depression with peak 6MWT SOB	**13**	**0.595**	**0.032**
Depression with SGRQ Symptoms	16	0.405	0.120
Depression with SGRQ Activity	**16**	**0.516**	**0.041**
Depression with SGRQ Impacts	**16**	**0.707**	**0.002**
Depression with Total SGRQ	**16**	**0.630**	**0.009**
Depression with MRC dyspnea score	**16**	**0.608**	**0.013**
Depression with BIPQ consequences	**16**	**0.717**	**0.002**
Depression with BIPQ Timeline	16	-0.092	0.736
Depression with BIPQ Personal Control	16	-0.231	0.390
Depression with BIPQ Treatment Control	16	-0.181	0.503
Depression with BIPQ Identity	**16**	**0.599**	**0.014**

Depression with BIPQ illness concern	**16**	**0.592**	**0.016**
Depression with BIPQ Coherence	16	-0.205	0.447
Depression with BIPQ emotional representation	**16**	**0.697**	**0.003**
Depression with overall BIPQ	**16**	**0.725**	**0.001**
Depression with Total Baecke	16	-0.078	0.782
Depression with average SOB with Activity	16	0.429	0.337
BIPQ score with Age	16	-0.224	0.461
BIPQ score with FEV_1 (%)	16	-0.024	0.955
BIPQ score with FVC (%)	16	-0.293	0.444
BIPQ score with FEV_1/FVC	16	0.477	0.194
BIPQ score with 6MWD	16	-0.407	0.167
BIPQ score with peak 6MWT SOB	16	0.539	0.057
BIPQ score with SGRQ Symptoms	16	0.277	0.299
BIPQ score with SGRQ Activity	16	0.275	0.303
BIPQ score with SGRQ Impacts	**16**	**0.587**	**0.017**
BIPQ score with Total SGRQ	16	0.461	0.072
BIPQ score with MRC Dyspnea Score	16	0.309	0.244
BIPQ score with anxiety	**16**	**0.558**	**0.025**
BIPQ score with depression	**16**	**0.725**	**0.001**
BIPQ score with Total Baecke	16	-0.261	0.347
BIPQ score with average SOB with Activity	16	0.214	0.645
Daily PA with age	10	0.502	0.168
Daily PA with FEV_1 (%)	10	-0.600	0.208
Daily PA with FVC (%)	10	-0.200	0.704
Daily PA with FEV_1/FVC	10	-0.143	0.787
Daily PA with 6MWD	10	-0.237	0.539
Daily PA with peak 6MWT SOB	10	-0.156	0.689
Daily PA with SGRQ symptoms	10	0.079	0.829
Daily PA with SGRQ activity	10	0.365	0.300
Daily PA with SGRQ impacts	10	-0.188	0.603
Daily PA with Total SGRQ	10	-0.006	0.987
Daily PA with MRC dyspnea score	10	0.302	0.397
Daily PA with Anxiety	10	0.269	0.453
Daily PA with Depression	10	0.183	0.613
Daily PA with BIPQ Consequences	10	0.079	0.828
Daily PA with BIPQ Timeline	10	-0.522	0.122
Daily PA with BIPQ Personal Control	10	0.511	0.131
Daily PA with BIPQ Treatment Control	10	0.000	1.000
Daily PA with BIPQ Identity	10	0.294	0.410
Daily PA with BIPQ Illness Concern	10	0.044	0.904
Daily PA with BIPQ Coherence	10	0.159	0.661
Daily PA with BIPQ Emotional Representation	10	0.332	0.348
Daily PA with Overal BIPQ	10	-0.042	0.907

Daily PA with Total Baecke	10	-0.615	0.058
Daily PA with Average SOB with Activity	10	0.393	0.383

2.5 Discussion

The intention of this research was to complete a longitudinal project following the participants from baseline to three months into their attendance of a pulmonary rehabilitation program. Use of a longitudinal study design would allow temporality to be assessed. The main question that was to be analyzed during this study regarding whether baseline anxiety, depression, and negative illness perceptions modulate the gains made in PR could not be answered due to a high drop-out rate in the PR program. There is recognition that some of the outcome measures (i.e. HRQoL and exercise capacity/physical activity) could also have impacted level of anxiety, depression, and illness perceptions, however, this could not be tested due to the fact that there were not enough participants who completed both the initial testing and the post-testing to complete the analyses required to answer this research question or the intended primary research question. The reasons for high numbers of drop-outs from the PR program during the time period of the study was not tracked so it cannot be determined whether it was related to participation in the study or to other reasons. The high drop-out rate is the most significant limitation of this study, as it made it impossible to answer the primary research question.

Secondary question 1 examined whether or not negative illness perceptions were associated with a higher level of depression and/or anxiety in individuals with COPD. We found that higher levels of depression were associated with more threatening illness perceptions. This is a novel finding in the COPD literature. However, the average HADS scores for both anxiety and depression for these participants actually placed them in the “normal” range (0-7). Previous literature has shown that HADS scores for anxiety range from 5.78 (Bentsen et al, 2013) to 9.31 (Al-Gamal, 2015) while scores for depression range from 4.55 (Bentsen et al, 2013) to 9.41 (Al-Gamal, 2015). This means that the result from this study is not abnormal when compared to the previous literature showing anxiety and depression levels in those with COPD are within the normal to mild range with the use of the HADS. Past studies including both illness perceptions and depression did not complete correlations to determine the relationships between them. There was also a significant correlation between illness perceptions and anxiety. This is confirming a previous study linking illness perceptions and anxiety using a different population (Husain et al, 2008). In COPD, individuals with higher anxiety tended to have stronger identity and chronicity beliefs and lower perceived control beliefs in their measured illness perceptions (Howard et al, 2009). It was also found in this study that more negative illness perceptions are positively correlated with HRQoL as measured by the SGRQ, meaning that as the BIPQ score increases so does the SGRQ score. The finding that more negative illness perceptions are associated with lower HRQoL is not new, as this relationship is among the most studied in the area of COPD and illness perceptions. More positive well-being has been associated with a weaker illness identity, less severe perceived consequences, decreased emotional reactions to and psychological attributions of their COPD (Scharloo et al, 2007; Scharloo et al, 2000; Hoth et al, 2011).

Secondary question 2 examined whether or not dyspnea levels as well as illness severity were associated with anxiety, depression, and illness perceptions. Unsurprisingly, dyspnea was associated with anxiety, depression, and illness perceptions. Dyspnea has the potential to be related to anxiety through shared stimulation of the limbic system, as both of these issues involve the amygdala, which is part of the limbic system (Amiri et al, 2012). Those with COPD who have lower levels of depression and higher levels of exercise have been found to generally have lower levels of dyspnea-related disability (Alexopoulos et al, 2014). There were no findings to support an affirmative answer to the part of this research question pertaining to illness severity and anxiety, depression, and illness perceptions. When attempting to correlate FEV_1 with any of the three independent variables, there were no significant findings that arose. To our knowledge, there has not been any literature examining the relationship between illness severity and illness perceptions so there were little in the way of expectations regarding these two topics. In past research, individuals with more severe COPD had higher levels of anxiety than those with mild COPD (Eisner et al, 2010) so it was surprising that this result was not supported in this research project. There may be a relationship there but with a low number of participants in this study, there may have been insufficient power to display this relationship. Other research has examined HRQoL with both illness severity and illness perceptions as independent variables (Mewes et al, 2015) but it was never investigated how level of airway obstruction correlates with illness representations. Illness severity has also been included in regression analyses to control for it as a potential confounder when analyzing illness perceptions and their relationship to exercise capacity (Zoeckler et al, 2014) but has not been directly linked with illness representations in COPD.

This study's results are parallel to the well-known relationships in individuals with COPD between anxiety and HRQoL and shortness of breath (Anzueto & Miravitlles, 2017; Ekici et al, 2015) but also extends this previous research by showing that illness perceptions are related to depression levels. Keeping in mind that depression levels are actually within what is considered to be normal values for the HADS. High levels of anxiety are typically associated with decreased HRQoL in many illness populations. It seems like common sense to see a link between anxiety and shortness of breath, although it is unknown if dyspnea causes anxiety or anxiety causes breathing problems. It may also be that they simply feed off of each other. Linking depression with HRQoL (Kwon & Kim, 2016), dyspnea (Perez et al, 2015; Einvik et al, 2015), and illness perceptions (Hyphantis et al, 2015) is also adding to the existing literature in the area of COPD. Like anxiety, higher levels of depression are related to lower quality of life and higher levels of shortness of breath. More threatening illness perceptions in an individual with COPD are also associated with a higher level of depression, which is a relatively novel concept in this area. This result is unsurprising as having a more negative outlook on your disease with respect to symptoms, manageability, and potential outcomes may lead to feelings of depression. Again, care needs to be taken in interpretation since mean levels of depression are actually within the normal category in this study population.

This study was limited in that it used a very small sample size due to both the size of the pulmonary rehabilitation program and the high drop-out rate of the participants from the PR program. This led to a stastistical power of 27%, which makes it more difficult to interpret the statistics used in the study. Having this small sample size meant that very few participants received an accelerometer so that much of the physical activity data was self-report instead of objectively measured.

The main strength of this study is that it is novel in the area of examining the relationship between illness perceptions and PR outcome measures in a COPD population. We found that more negative illness representations were associated with higher levels of exertional shortness of breath, anxiety, and depression in participants in pulmonary rehabilitation with COPD while severity of airway obstruction and physical activity levels were not related to illness perceptions. Previous research has studied typical perceptions of COPD in a PR setting (Fischer et al, 2010), but not how they are related to other outcome measures. The finding that more negative illness perceptions are related to higher levels of depression is not unexpected, as one would anticipate that an individual who takes a more threatening view of their illness to be at least somewhat depressed. Fischer and colleagues (2010) examined dyspnea and illness perceptions in a PR COPD population but did not complete any correlation analyses to attempt to investigate a relationship between the two variables. Other strengths of this study include using validated measures for anxiety, depression, and illness perceptions along with the use of an objective measure of physical activity (accelerometry) and lung function.

Future research in this area should focus on a larger sample size so that, even with drop-outs, pre and post-data could be compared to determine if there is a change in levels of anxiety and depression, as well as changes in participants' illness perceptions and the relationship these outcomes have to physical activity levels and shortness of breath. Future research should also ensure that all participants receive an accelerometer for more accurate physical activity monitoring.

2.6 Conclusions

Negative illness perceptions are related to higher levels of dyspnea, anxiety, depression, and poorer quality of life in those with COPD but not physical activity levels. Higher levels of both anxiety and depression are significantly related to higher levels of exertional dyspnea, poorer quality of life, and higher levels of general shortness of breath. Daily self-reported physical activity was not related to any other measured variables.

2.7 References

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Chapter 3 - Determinants of Physical Activity in Individuals with Airway Obstruction – An Analysis of the Canadian Health Measures Survey

3.1 Abstract

Background – Obstructive lung disease (specifically chronic obstructive lung disease) is associated with decreased physical activity levels. Quality of life and mental health are affected in those with obstructive lung disease, and this can impact physical activity levels. The goals of this study were to determine which measures that were used in the Canadian Health Measures Survey would help predict physical activity in an obstructed lung disease population.

Methods – The CHMS was analyzed using both weighted simple and multiple regressions to investigate determinants of physical activity in those with obstructive lung disease. Accelerometry was used to measure physical activity levels at various intensities while household questionnaire data and mobile clinic data was used to look at spirometry, and self-reported measures of health, mental health, and quality of life.

Results – This study employed a sample size of 686, representative of >3,800,000 individuals with obstructive breathing patterns (mean FEV_1/FVC of 64.11) who were 58±0.69 years of age on average. This group averaged 7197 steps and achieved 14.77 minutes of moderate to vigorous physical activity per day. There were many predictors for physical activity across a variety of intensities and a variety of disease severity levels but self-perceived health, disability level, shortness of breath with simple chores, and frequent persistent colds were among the most common correlates of physical activity.

Conclusions – Not surprisingly, Canadians with obstructive breathing patterns do not meet daily physical activity recommendations. In adjusted analyses the following were found to help predict various physical activity measures: dyspnea from simple chores, frequent persistent colds, self-perceived health and mental health, quality of life, life satisfaction, disability level, grip strength, as well as sit and reach measurements.

3.2 Introduction

Chronic obstructive pulmonary disease (COPD) is a respiratory condition that impacts an estimated 17% of Canadians aged 35-79 years (Evans et al, 2014). COPD is characterized by dyspnea due to progressive obstruction of the airways and dynamic hyperinflation (O'Donnell et al, 2008). The diagnosis of COPD is indicated by spirometry results showing an FEV_1/FVC <70% (O'Donnell et al, 2008).

Physical activity is often limited to varying degrees in individuals with COPD. People suffering from COPD have been found to have physical activity levels that are 57% that of their unaffected counterparts (Bossenbroek et al, 2011). They also tend to spend more time in sedentary positions (i.e. sitting, supine) and less time in active positions (i.e. standing, walking) than healthy controls (Bossenbroek et al, 2011). A small proportion of individuals who have COPD achieve the recommended 30 minutes of physical activity per day (Canadian Society for Exercise Physiology, 2011) and only 27% of those with mild, 10% of those with moderate, and 17% of those with severe COPD are able to reach that 30-minute benchmark (Eliason et al, 2011). People with COPD are sedentary 82% of their time, compared to 68% in age-matched controls (Vorrink et al, 2011). This decrease in physical activity levels often begins prior to a diagnosis of COPD and before the onset of breathlessness (Gouzi et al, 2011).

An individual's level of physical activity has the potential to impact health, and subsequently, healthcare costs for those with COPD. Those with lower physical activity levels have higher levels of dyspnea, increased number of comorbidities, increased airway obstruction, and more hospital admissions compared to those with higher levels (Esteban et al, 2010). When physical activity levels increase, both mortality and hospitalization risk drop (Garcia-Rio et al, 2009). Quality of life and physical activity levels have also been linked in both healthy older adults (Pucci et al, 2012) and individuals with COPD (Durr et al, 2014) with higher physical activity levels being associated with better health related quality of life (HRQoL) in individuals diagnosed with COPD (Esteban et al, 2010). Increases in exercise capacity are associated with improved HRQoL (Mador et al, 2011) and decreases are associated with a higher chronic disease burden (Nguyen et al, 2012).

Mental health measures have also been shown to be related to physical activity levels. In middle aged and older adults, a bidirectional relationship has emerged with higher levels of physical activity being related to more positive mental health and lower levels of activity being associated with poorer mental health (Steinmo et al, 2014). Similar results have been replicated in a COPD population with 10 minutes or more per day of walking having a positive effect on self-reported mental health (Shiue, 2015).

The quantification of physical activity in individuals with COPD has been done in a multitude of ways, including direct measurement (pedometers, heart rate monitors, accelerometers, integrated multisensory systems, and video analysis) and estimation (activity diaries, physical activity recall questionnaires). The use of self-report estimation methods tends to have limited accuracy because those with COPD tend to underestimate the amount of time spent sedentary and overestimate the amount of time spent participating in physical activity (Pitta et al, 2005). Triaxial accelerometers tend to be the most user friendly method of physical activity tracking and are also very accurate when compared to video analysis in a COPD population (Pitta et al, 2005).

With such a dramatic impact of decreased physical activity levels on individuals suffering from COPD, and with such a large proportion of our population being affected by the disease, there needs to be further investigation into the correlates of physical activity levels in Canadians with COPD. The Canadian Health Measures Survey (CHMS) includes measures of physical activity, lung function, quality of life, self-reported health and mental health measures collected from across Canada. The main purpose of this study is to determine which of these measures utilized in Statistics Canada's CHMS best predict physical activity levels amongst those aged 35 and older with spirometry indicative of obstructive lung disease.

3.3 Methods

Access was granted to the Statistics Canada Research Data Centre's (RDC) confidential CHMS data (Cycles 1-3) through a rigorous application process, including a criminal record check and detailed research proposal submission. Confidentiality was of utmost importance due to potential identifying information, therefore all data analyses were required to be weighted and the RDC analyst needed to approve all results before they could be vetted from the RDC office. Since the research project approval is so rigorous, ethics approval is not required for RDC research projects.

The CHMS used a cross-sectional sample survey to collect general health data from Canadians age 3-79 through the use of both interviews and physical measures (Statistics Canada, 2014). They were sampled voluntarily from both urban and rural areas in numbers according to the area's population. Samples excluded those who live on reserve, members of the Canadian Armed Forces, and those living in institutions (Statistics Canada, 2014). Five regions were identified for sampling in order to ensure adequate representation of the Canadian population (Atlantic, Quebec, Ontario, Prairies [including Yellowknife], and British Columbia [including Whitehorse]) with the number of data collection sites set up in each region relating to the populations represented (Statistics Canada, 2014). Samples were restricted to the populations within 50 km of the mobile clinics or 75 km in rural areas (Statitics Canada, 2014). Census Canada data was used to determine the date of birth of household members and households were selected based on age group representation within the sample (Statistics Canada, 2014). Once a dwelling was selected for participation, 1-2 members of the household were randomly selected to participate (Statistics Canada, 2014). Mobile clinic sites were not set up in the territories, Saskatchewan, or Prince Edward Island in any of the 3 cycles that were included in this study.

The CHMS data set includes both household questionnaire data, as well as mobile clinic data from across Canada, collected from 2009-2013. Cycles 1-3 were used in this study and the data from these cycles was merged into one larger data-set through the use of a weighting coefficient that was the same for all cycles. Information was collected both objectively and through self-report about past medical history, environmental exposures, general fitness and nutrition as well as previous exposures to any infectious diseases. Blood and urine samples were obtained, along with measures of lung function, vital signs and anthopometry. The dependent variables included in this study include accelerometry data, broken down into mean number of minutes engaged in light physical activity, moderate physical activity, vigorous physical activity, moderate to vigorous physical activity, total physical activity, sedentary time, and mean number of steps taken in a day. The independent variables in this study include self-perceived health, satisfaction with life in general, self-perceived mental health, self-perceived stress, self-perceived quality of life, frequent persistent colds, wheeze from exertion, simple chores make SOB, age, sex, percent of predicted forced vital capacity (FVC), percent of predicted forced expiratory volume in one second (FEV_1), and FEV_1/FVC. These variables were consistent throughout the cycles used in this study.

3.3.1 Accelerometry

Actical activity monitors were dispensed to all eligible participants, along with a shipping envelope for their return and an information sheet on proper use of the monitor. Each participant was instructed to wear the activity monitor for seven days and then return it to the CHMS researchers via prepaid shipping envelope. All accelerometry data was amalgamated into one file and those data files that were considered non-valid were dropped. Only those files with at least one day of 10 or more hours of data collection were accepted.

3.3.2 Household questionnaire data

Self-perceived health, life satisfaction, mental health, stress levels, and quality of life were all measured via 5-point Likert-type scales. In order to have an adequate unweighted sample size of participants, the responses were re-categorized into three groups. The questions used can be found in Table 3.1. Use of self-rated health as a question has been found to be a reliable indicator of health in adults (Lundberg & Manderbacka, 1996) while self-reported mental health has been shown to be predictive of mental, physical, social, and resource utilization variables (Ahmad et al, 2014). Single item quality of life scales (Yohannes et al, 2011), stress scales (Elo et al, 2003), and life satisfaction scales (Cheung & Lucas, 2014) have been shown to be as reliable and valid as other multi-item scales. Questions were also asked in the household questionnaire about smoking status, comorbidities, and disability level. Disability level was measured by the Disability Screening Questions (DSQ) which specifically investigates sensory, physical, cognitive, and mental health related disability (Grondin, 2016). The total score is then categorzied into four categories: no disability, mild disability, moderate disability and severe disability (Grondin, 2016). For the purposes of this study, these categories were collapsed into a dichotomous variable: no disability/mild disability and moderate/severe disability. Comorbidities included in the analysis included arthritis, diabetes, heart disease, and cancer. Smoking status included the number of years an individual had smoked.

Table 3.1 – Household Questionnaire Questions

Question	Responses
In general, would you say your health is?	1. Excellent to very good 2. Good 3. Fair to poor
How satisfied are you with your life in general?	1. Very satisfied to satisfied 2. Neither satisfied nor dissatisfied 3. Dissatisfied to very dissatisfied
In general, would you say your mental health is?	1. Excellent to very good 2. Good 3. Fair to poor
Thinking about the amount of stress in your life, would you say that most days are?	1. Not at all stressful to not very stressful 2. A bit stressful 3. Quite a bit stressful to extremely stressful
Would you rate your quality of life as?	1. Excellent to very good 2. Good 3. Fair to poor

3.3.3 Mobile clinic data

Race adjusted spirometry was completed with a Koko Pneumotach spirometer according to the American Thoracic Society standards (Miller et al, 2005). Both verbal instructions and a demonstration were completed prior to the administration of spirometry. Each subject completed a minimum of three acceptable trials over a maximum of eight attempts with the best effort being determined by summing FVC and FEV_1. Other than having no post-bronchodilator spirometry completed, the Global Initiative for Obstructive Lung Disease (GOLD) criteria were used for spirometry (Global Initiative for Chronic Obstructive Lung Disease, 2009). Reference values from the NHANES III were used to determine upper and lower limit of normal values (Hankinson et al, 1999). The Canadian Thoracic Society guidelines were used for COPD severity categorization (O'Donnell et al, 2007).

3.3.4 Data Analysis

All analyses were run using Stata version 12 (StataCorp, 2011). Data was weighted to approximate the Canadian population with the use of sampling weights. These weights were used in order to account for the probability being unequal of being asked to complete the survey. Bootstrapping was used on the data in order to obtain confidence intervals and standard errors. For these analyses, statistical significance was set as $p<0.05$. Analysis was limited to subjects aged 35 years and older with an FEV_1/FVC of less than 0.70. Individuals who self-reported as having a diagnosis of asthma were removed from the sample in order to only include those that are most likely representative of a COPD diagnosis. Simple regressions were run in order to determine significant relationships between dependent and independent variables for both all levels of obstruction together as well as each separate level of severity (mild, moderate, and severe to very severe). The model-building strategy known as purposeful selection of covariates as outlined by Hosmer and colleagues (2013) was then used to select variables to enter into multiple regression models for each physical activity measure and each level of airway obstruction. Age, sex, total household income, and smoking status were used as control variables in all multiple regressions while the comorbidities of heart disease, cancer, diabetes, and arthritis as well as bmi were used as control variables when found to significantly contribute to the multiple regression equations using the model building strategy. Consistent models were used for the same dependent variable across levels of airway obstruction. However, models varied between dependent variables.

3.4 Results

The actual number of participants included in this study was 686 while weighted results gave a total population size of >3,800,000 with a mean age of 58 years. Their mean percent of predicted FEV_1 was 80.15%, meaning that they may be deemed to have borderline severity between mild and moderate obstruction. The full population averaged 7,197 steps and achieved 14.77 minutes of moderate to vigorous physical activity per day. Please see Table 3.2 for all population characteristics.

Approximately half (53%) of the population was deemed to have mild airway obstruction. This group had a mean age of 59 years and their average percent of predicted FEV_1 was 92.13%. Among those with mild airway obstruction, they averaged 7,828 steps and 17.91 minutes of moderate to vigorous physical activity per day. Approximately 42% of this sample had moderate airway obstruction. This group had a mean age of 57 years with their average percent of predicted FEV_1 being 69.97%. They averaged 6,683 steps and 11.81 minutes of moderate to vigorous physical activity per day. Five percent of this sample presented with severe airway obstruction. This group had a mean age of 63 years with an average percent of predicted FEV_1 of 37.29%. They averaged 4,872 steps and 6.32 minutes of moderate to vigorous physical activity per day.

Table 3.2 – Total population characteristics

	All levels of severity		Mild		Moderate		Severe/Very Severe	
Variable	N	Mean ± SE	N	Mean ± SE	N	Mean ± SE	N	Mean ± SE
Age (years)	3836260	58 ± 0.69	2048069	59 ± 0.94	1594185	57 ± 0.89	194006	63 ± 2.42
Sex (percent female)	3836260	43.43%	2048069	40.62%	1594185	46.40%	194006	48.70%
Percent of predicted FVC (%)	3836260	95.38 ± 1.00	2048069	106.30 ± 0.66	1594185	85.25 ± 1.05	194006	63.40 ± 3.12
Percent of predicted FEV_1 (%)	3836260	80.15 ± 1.23	1429646	92.13 ± 0.75	1594185	69.97 ± 0.75	194006	37.29 ± 2.90
FEV_1/FVC (%)	3836260	64.11 ± 0.00	2048069	66.48 ± 0.00	1594185	63.46 ± 0.01	194006	44.46 ± 0.03
BMI	3829462	26.78 ± 0.25	2041271	25.94 ± 0.33	1594185	28.11 ± 0.54	194006	24.70 ± 1.66
Years smoked	1486891	24.84 ± 1.47	733866	21.74 ± 1.19	676349	26.20 ± 2.76	76675	42.39 ± 2.88
Total household income	3836260	64131.11 ± 2531.75	2048069	68234.52 ± 4758.71	1594185	61455.92 ± 3107.63	194006	42795.01 ± 7907.14
Has diabetes (% yes)	3833372	5.58%	2045181	4.94%	1594185	6.78%		
Has heart disease (% yes)	3836260	8.16%	2048069	4.84%	1594185	12.79%		
Has cancer (% yes)	3836260	2.47%						
Disability level (/2)	3742040	1.34 ± 0.02	1998616	1.33 ± 0.02	159419	1.35 ± 0.04	194006	1.3 ± 0.14
Self-perceived health (/3)	3832747	1.77 ± 0.05	2044556	1.64 ± 0.05	1594185	1.84 ± 0.08		
Satisfaction with life in general (/3)	3825593	1.20 ± 0.03	2041066	1.17 ± 0.03	1590521	1.24 ± 0.08		
Self-perceived mental health (/3)	3832596	1.35 ± 0.04	2048069	1.34 ± 0.03	1590521	1.34 ± 0.08		

Self-perceived stress (/3)	3835481	1.69 ± 0.04	2047291	1.64 ± 0.04	1594185	1.75 ± 0.10		
Self-perceived quality of life (/3)	3832596	1.49 ± 0.04	2048069	1.42 ± 0.03	1590521	1.54 ± 0.07		
Average daily light physical activity (min)	3612735	201.82 ± 7.86	1913646	213.74 ± 9.09	1511542	190.64 ± 9.77	187548	170.37 ± 59.20
Average daily moderate physical activity (min)	3601008	13.59 ± 1.38	1908009	16.29 ± 1.67	1511542	11.08 ± 2.02	181456	5.96 ± 2.46
Average daily vigorous physical activity (min)	3632467	2.17 ± 0.59	1929673	3.04 ± 0.91	1515245	0.73 ± 0.43	187548	4.84 ± 3.44
Average daily moderate to vigorous physical activity (min)	3601008	14.77 ± 1.49	1908009	17.91 ± 1.80	1511542	11.81 ± 2.12	181456	6.32 ± 2.54
Average daily total physical activity (min)	3601008	212.17 ± 7.71	1908009	227.56 ± 10.12	1511542	202.10 ± 10.17	181456	134.29 ± 36.66
Average daily steps	3632467	7197 ± 320	1929673	7828 ± 391	1515245	6683 ± 443	187548	4872 ± 1546
Average daily sedentary time (min)	2100828	203.39 ± 11.85	1177549	214.83 ± 12.92	825705	177.64 ± 10.42	97574	283.27± 79.85
Cough regularly (% yes)	3836260	26.25%	2048069	18.39%	1594185	31.97%	194006	62.22%
Cough up phlegm regularly (% yes)	3836260	21.70%	2048069	20.24%	1594185	20.38%	194006	48.00%
Simple chores make you short of breath (% yes)	3836260	15.73%	2048069	7.68%	1594185	18.96%	194006	74.26%
Wheeze on exertion (% yes)	3836260	14.74%	2048069	6.51%	1594185	21.45%	194006	46.51%
Frequent persistent colds	3836260	6.88%	2048069	6.07%	1594185	7.26%		
Grip strength (lbs)	3795094	70.33 ± 1.49	2046638	73.27 ± 2.08	1581511	67.36 ± 2.51	166945	62.44 ± 5.25
Sit and reach (cm)	2774844	24.62 ± 0.79	1444769	26.33 ± 1.01	1232075	22.55 ± 0.99	98002	25.60 ± 3.01

Partial curl ups completed in one minute	2414683	10.13 ± 0.64	1329450	12.43 ± 0.98	1021132	7.13 ± 1.22	64102	10.15 ± 6.45

For simple regression results, please see table 3.3. When looking at self-perceived mental health as a predictor, it was not significantly associated with physical activity of any intensity level. Self-perceived quality of life was significantly related to average daily moderate PA and moderate to vigorous PA in those with mild obstruction and to average daily total PA and average daily steps in those with severe to very severe obstruction. Life satisfaction was significantly related to average daily light PA, vigorous PA, and total daily PA in all levels of airway obstruction together and mild obstruction and to daily steps in those with mild obstruction. Self-perceived health was significantly related to moderate PA, vigorous PA, and moderate to vigorous PA in those with mild obstruction. This same variable was also significantly related to daily light PA, daily moderate PA, daily moderate to vigorous PA, total daily PA and daily steps in those with moderate obstruction. This variable is also significantly related to light PA, moderate PA, vigorous PA, moderate to vigorous PA, total PA, and daily steps in the all levels of obstruction group. Lastly in the group of individuals with severe to very severe obstruction, self-perceived health is related to average daily steps. These variables worsened as level of obstruction increased.

Having frequent persistent colds was significantly associated with many activity variables. For moderate obstruction, it was associated with daily light PA, moderate PA, moderate to vigorous PA, and total PA. It was also related to moderate, moderate to vigorous, and total PA in those with all levels of obstruction. Wheeze from exertion was significantly linked to light PA, total daily PA, and daily steps in those with moderate obstruction and linked to light PA, daily sedentary time, and daily steps in all levels of obstruction together. The variable regarding simple chores making an individual breathless was significantly related to moderate daily PA, moderate to vigorous PA, and total daily PA in those with moderate obstruction. It was also linked to light PA, moderate PA, moderate to vigorous PA, total daily PA, and daily sedentary time in all levels of obstruction together as well as to moderate daily PA in those with mild airway obstruction. The variables of coughing regularly and coughing up phlegm regularly were not found to be significantly related to any physical activity variables. All of these variables were more frequently reported as level of airway obstruction increased.

There were only two other variables used as predictors that were not control variables that were found to be significant: grip strength and partial curl-ups performed in one minute.

Grip strength was significantly related to light physical activity in all levels of obstruction together as well as in mild, moderate, and severe obstruction separately. It was also associated with total daily PA in all obstruction together, mild obstruction, moderate obstruction, and severe to very severe obstruction. Grip strength also had a significant relationship with moderate physical activity in those with all levels of severity and severe to very severe obstruction, with moderate to vigorous PA in those with mild obstruction and those with severe to very severe obstruction, and with average daily steps in those with all levels of obstruction and moderate obstruction. Partial curl ups performed in one minute was related to moderate and moderate to vigorous daily physical activity levels in those with all levels of obstruction together. Please see Table 3.3 for simple regressions in all levels of airway obstruction.

For all multiple regression equations, the following variables were used as controls: years smoked, age, sex, and total household income. For average daily light physical activity, the multiple regression equation found to fit the various levels of severity best included years smoked, age, sex, total household income, disability level, life satisfaction, frequent persistent colds, grip strength, and sit and reach measure. This equation did not achieve statistical significance in those with severe/very severe obstruction. For average moderate physical activity, the multiple regression equation found to fit the various levels of severity best included years smoked, age, sex, total household income, self-perceived health, self-perceived mental health, arthritis, and diabetes. This equation did not achieve statistical significance in those with severe/very severe obstruction. For average vigorous physical activity, there was not a common multiple regression equation that achieved statistical significance across levels of obstruction. For moderate to vigorous daily physical activity, the multiple regression equation best fitting the various levels of severity included years smoked, age, sex, total household income, simple chores make an individual dyspneic, self-perceived quality of life, self perceived mental health, and bmi. This equation did not achieve statistical significance in those with severe/very severe obstruction. The variable total daily physical activity was found to have the following multiple regression equation to best fit the various levels of severity: years smoked, age, sex, total household income, and simple chores making the individual short of breath. This equation did not achieve statistical significance in those with severe/very severe obstruction. For the variable of average daily sedentary time, it was found that the multiple regression equation that best fit the levels of severity included years smoked, age, sex, total household income, and simple chores making the individual short of breath. This equation did not achieve statistical significance in those with mild, moderate, and severe/very severe obstruction. Lastly for the variable of average daily steps, the following variables were used in a multiple regression equation: years smoked, age, sex, total household income, BMI, and satisfaction with life in general. This equation did not achieve statistical significance in those with severe/very severe obstruction. Please see table 3.4 for the detailed results of the multiple regression equations.

Table 3.3 – Significant Simple Regressions Between Physical Activity and Potential Correlates for All Levels of Severity

	All obstruction				Mild obstruction				Moderate Obstruction				Severe/Very Severe Obstruction			
Variables	β	SE	*p*	R^2	β	SE	*p*	R^2	β	SE	*p*	R^2	β	SE	*p*	R^2
Average Daily Light PA																
Age	-2.59	0.46	<0.001	0.067	-2.56	0.68	<0.001	0.072	-2.46	0.70	<0.001	0.096	-7.05	3.01	0020	0.055
Sex	-27.97	11.27	0.013	0.014					-29.05	13.50	0.031	0.023				
Self-perceived health	-31.87	5.76	<0.001	0.041					-38.42	6.07	<0.001	0.098				
Life satisfaction	-36.87	11.33	0.001	0.028	-53.69	15.53	0.001	0.048								
Arthritis	44.05	11.80	<0.001	0.028					50.34	15.60	0.001	0.056				
Diabetes	74.06	18.94	<0.001	0.021					82.63	19.72	<0.001	0.047				
Heart disease	44.70	18.89	0.018	0.011					48.82	17.32	0.005	0.029				
Disability level	-47.24	11.36	<0.001	0.035					-57.77	13.69	<0.001	0.083				
Years smoked	-1.47	0.51	0.004	0.051	-1.41	0.64	0.027	0.041								
Simple chores make SOB	39.99	15.47	0.010	0.015												
Wheeze from exertion	36.99	14.39	0.010	0.012					38.39	13.84	0.006	0.027				
Frequent persistent colds									50.24	13.68	<0.001	0.019				
BMI									-2.84	1.10	0.010	0.029				
Grip strength	0.94	0.24	<0.001	0.037	0.60	0.28	0.025	0.017	0.96	0.35	0.006	0.054	5.54	2.57	0.031	0.179
Average Daily Moderate PA																
Self-perceived health	-5.84	1.33	<0.001	0.071	-4.53	1.71	0.008	0.031	-5.89	2.64	0.026	0.099				
Self-perceived quality of life					-4.49	2.23	0.044	0.021					-5.02	2.16	0.020	0.230
Self-perceived stress	-9.68	4.82	0.045	0.003												
Age	-0.35	0.09	<0.001	0.064	-0.26	0.08	0.002	0.029	-0.47	0.18	0.011	0.148				
Sex	-7.92	1.72	<0.001	0.056	-7.11	2.47	0.004	0.038	-8.05	3.45	0.020	0.075				
Cancer	9.45	1.65	<0.001	0.008	13.77	3.41	<0.001	0.005	6.46	2.77	0.020	0.009	6.05	2.51	0.016	0.007
Arthritis	8.45	1.65	<0.001	0.052	10.47	1.97	<0.001	0.067	6.07	2.72	0.026	0.035				
Diabetes	6.98	2.13	0.001	0.010	8.76	2.91	0.003	0.012					6.26	2.70	0.021	0.024
Heart disease	5.70	2.48	0.021	0.009												
Disability level	-15.72	7.85	0.045	0.004												
Years smoked	-0.42	0.17	0.014	0.147					-0.71	0.31	0.019	0.355				
Total Household Income	0.00	0.00	0.011	0.036												
Simple chores make SOB	6.07	2.73	0.026	0.018	0.00	0.00	0.040	0.061	6.54	2.68	0.015	0.030				
Frequent persistent colds	4.84	2.45	0.048	0.006					6.48	2.44	0.008	0.014				
% of predicted FVC	0.22	0.05	<0.001	0.053												
% of predicted FEV1	0.17	0.05	0.001	0.034												
Grip strength	0.21	0.05	<0.001	0.093									0.29	0.09	0.002	0.400
Partial curl ups in one minute	0.33	0.15	0.023	0.044												
Average Daily Vigorous PA																
Life satisfaction	-1.38	0.45	0.002	0.002	-2.10	0.84	0.013	0.003								
Self-perceived stress	-1.76	0.78	0.025	0.007												
Cancer	2.03	0.67	0.002	0.000	3.06	0.92	0.001	0.000								
Disability level	-2.14	1.10	0.050	0.004												
Years smoked	-0.08	0.04	0.047	0.013	-0.13	0.06	0.028	0.020								
Average Daily Moderate to Vigorous PA																
Self-perceived health	-6.67	1.34	<0.001	0.075	-5.54	1.79	0.002	0.036	-6.49	2.67	0.015	0.101				
Self-perceived quality of life					-5.86	2.20	0.008	0.027					-5.52	2.20	0.012	0.250

Age	-0.38	0.10	<0.001	0.061	-0.30	0.09	0.002	0.030	-0.50	0.19	0.010	0.140				
Sex	-8.55	1.80	<0.001	0.053	-7.78	2.78	0.005	0.036	-8.45	3.46	0.015	0.069				
Arthritis	9.06	1.69	<0.001	0.048	11.47	2.11	<0.001	0.063	6.14	2.77	0.027	0.030				
Diabetes	7.89	2.27	0.001	0.010	9.76	3.17	0.002	0.011					6.65	2.79	0.017	0.024
Heart disease	5.89	3.00	0.050	0.008												
Cancer	10.45	1.73	<0.001	0.008	15.40	3.37	<0.001	0.005	6.94	3.13	0.027	0.009	6.42	2.60	0.014	0.007
Disability level	-0.78	0.26	0.003	0.014												
Years smoked	-0.47	0.17	0.005	0.150					-0.71	0.30	0.019	0.342				
Total household income	0.00	0.00	0.004	0.050	0.00	0.00	0.022	0.073								
Simple chores make SOB	7.22	2.70	0.008	0.021					7.27	2.80	0.009	0.032				
Frequent persistent colds	5.64	2.74	0.040	0.006					10.48	4.47	0.019	0.002				
% of predicted FVC	0.25	0.06	<0.001	0.052					6.70	2.76	0.015	0.012				
% of predicted FEV1	0.20	0.06	<0.001	0.036												
Grip strength					0.20	0.06	0.002	0.062					0.31	0.10	0.002	0.389
Partial curl ups in one minute	0.41	0.15	0.006	0.054												
Average Daily Total PA																
Self-perceived health	-42.45	5.67	<0.001	0.096	-24.86	9.79	0.011	0.029	-44.64	6.46	<0.001	0.116	-91.22	32.6	0.005	0.392
Life satisfaction	-32.27	14.54	0.026	0.029	-54.21	17.49	0.002	0.063								
Self-perceived quality of life													-68.58	31.4	0.029	0.2957
Age	-3.10	0.48	<0.001	0.126	-3.03	0.66	<0.001	0.129	-2.94	0.70	<0.001	0.120	-5.24	2.48	0.035	0.178
Sex	-31.36	10.24	0.002	0.022					-37.19	13.70	0.007	0.033				
Arthritis	49.93	11.24	<0.001	0.046	42.39	17.23	0.014	0.035	56.18	15.88	<0.001	0.062				
Diabetes	77.61	19.79	<0.001	0.031					87.74	20.31	<0.001	0.047				
Heart disease	53.11	17.22	0.002	0.020					52.54	19.43	0.007	0.030				
Cancer	48.60	22.37	0.030	0.005					42.17	17.07	0.014	0.008	134.82	37.1	<0.001	0.023
Disability level	-45.96	12.25	<0.001	0.044	-33.74	16.93	0.046	0.025	-56.48	17.62	0.001	0.069				
Years smoked	-1.95	0.50	<0.001	0.076	-1.60	0.76	0.034	0.047								
Simple chores make SOB	46.18	17.69	0.009	0.027												
Wheeze on exertion	41.40	13.60	0.002	0.020					40.07	14.71	0.007	0.026				
Frequent persistent colds	43.78	20.83	0.036	0.012					56.73	14.24	<0.001	0.021				
BMI									-3.03	1.25	0.016	0.029				
FEV_1/FVC	227.77	113.44	0.045	0.023												
% of predicted FEV_1	1.18	0.54	0.028	0.039												
Grip strength	1.13	0.23	<0.001	0.070	0.87	0.30	0.004	0.009	1.17	0.32	<0.001	0.071	2.60	0.97	0.007	0.262
Average Daily Sedentary Time																
Life satisfaction	-40.90	13.43	0.002	0.020												
Self-perceived stress	-23.11	9.79	0.018	0.012	-20.91	8.42	0.013	0.010								
Age	1.40	0.40	<0.001	0.012	1.30	0.50	0.009	0.010	1.61	0.70	0.022	0.034				
Diabetes													277.23	77.9	<0.001	0.017
Cancer													277.23	77.9	<0.001	0.017
Disability level	-40.98	17.33	0.018	0.016					-34.08	17.14	0.047	0.022				
Simple chores make SOB	36.40	16.39	0.026	0.008												
Wheeze from exertion	27.88	12.54	0.026	0.005												
BMI	-2.67	1.29	0.038	0.008					-4.37	1.79	0.014	0.059				

Average Daily Steps																
Self-perceived health	-1716.02	279.98	<0.001	0.090					-2093.0	426.48	<0.001	0.168	-4491	1279	<0.001	0.535
Life satisfaction					-1714.5	790.2	0.030	0.032								
Self-perceived QOL													-2617	1254	0.037	0.239
Age	-95.44	21.33	<0.001	0.069	-68.63	32.46	0.035	0.034	-117.46	33.74	0.001	0.125	-280.7	139	0.044	0.285
Sex									-2348.6	558.90	<0.001	0.086				
Arthritis	1645.13	523.23	0.002	0.029					2135.32	834.58	0.011	0.058				
Heart disease	1808.76	644.81	0.005	0.013	1426.0	672.78	0.034	0.005								
Diabetes	2439.80	865.32	0.005	0.018					3274.97	670.35	<0.001	0.042				
Cancer	2303.06	912.90	0.012	0.007					2008.52	823.65	0.015	0.011	4904	1549	0.002	0.017
Disability level					-1366.2	647.90	0.035	0.021								
Years smoked	-108.31	22.78	<0.001	0.143					-126.33	44.95	0.005	0.228				
Wheeze on exertion	1660.95	544.65	0.002	0.019					1496.09	725.03	0.039	0.024				
BMI	-107.78	50.27	0.032	0.016					-159.56	53.02	0.003	0.052				
% predicted FVC	53.00	20.31	0.009	0.043												
% predicted FEV1	46.95	19.97	0.019	0.036					122.47	55.75	0.028	0.057				
Grip strength	41.93	9.17	<0.001	0.055					54.65	16.65	0.001	0.101				

This table shows only statistically significant simple regressions.

Table 3.4 – Multiple Regressions Between Physical Activity and Potential Predictors for All Levels of Severity

	All Obstruction		Mild Obstruction		Moderate Obstruction		Severe/Very Severe Obstruction	
Variables	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Average Daily Light PA	R^2=0.2747	*p*=0.000	R^2=0.3520	*p*=0.000	R^2=0.3793	*p*=0.003	Not significant	
Years smoked	0.94	0.59	0.63	0.80	2.42	1.58		
Age	-4.22	1.27**	-3.34	1.54*	-7.31	2.29**		
Sex	-35.77	37.92	-2.34	39.37	-92.86	77.79		
Total household income	-0.00	0.00	-0.00	0.00	-0.00	0.00		
Disability level	-18.30	19.28	-35.33	21.16	16.33	39.02		
Life satisfaction	-56.42	38.89	-69.89	42.96	-50.19	136.61		
Frequent persistent colds	64.36	26.79*	78.18	54.00	62.13	58.32		
Grip strength	-12.71	0.81	0.24	1.07	-1.05	2.11		
Sit and reach	1.70	0.58**	1.52	0.77*	-0.24	1.87		
Average daily moderate PA	R^2=0.383	*p*=0.000	R^2=0.204	*P*=0.000	R^2=0.669	*P*=0.001	Not significant	
Years smoked	-0.07	0.10	0.07	0.16	-0.11	0.13		
Age	-0.36	0.13**	-0.16	0.13	-0.50	0.20*		
Sex	-7.07	1.71**	-4.88	2.83	-8.25	2.72**		
Total household income	-0.00	0.00	0.00	0.00	-0.00	0.00		
Self-perceived health	-4.44	1.99*	-1.13	2.33	-2.64	2.26		
Self-perceived mental health	6.02	3.10	-2.56	1.89	9.75	4.19*		
Arthritis	2.62	1.56	6.90	2.26**	-0.17	3.05		
Diabetes	2.07	2.30	5.89	3.52	-0.01	3.61		
Average daily vigorous PA	Not significant		Not significant		Not significant		Not significant	
Average daily moderate to vigorous PA	R^2=0.322	*p*=0.000	R^2=0.171	*p*=0.001	R^2=0.652	*p*=0.002	Not significant	
Years smoked	-0.19	0.15	-0.05	0.20	-0.16	0.12		
Age	-0.31	0.15*	-0.16	0.17	-0.44	0.21*		
Sex	-7.14	2.01**	-4.72	3.37	-8.41	3.22**		
Total household income	0.00	0.00	-0.00	0.00	-0.00	0.00		
Simple chores make SOB	4.80	2.06*	2.94	4.95	5.48	3.44		

Self-perceived quality of life	0.25	2.28	-3.76	4.95	2.04	2.85		
Self-perceived mental health	5.64	2.83*	-1.58	3.13	8.75	4.07*		
Arthritis	3.64	1.37**	5.76	3.15	0.41	3.06		
Average daily total PA	R^2=0.342	*p*=0.000	R^2=0.319	*p*=0.000	R^2=394	*p*=0.000	Not significant	
Years smoked	0.19	0.53	-0.11	0.77	1.47	0.93		
Age	-4.16	0.86**	-4.49	1.06**	-5.18	1.35**		
Sex	-48.07	16.77**	-30.39	20.35	-58.55	23.39*		
Total household income	-0.00	0.00	-0.00	0.00	-0.00	0.00		
Disability level	-37.44	13.47**	-40.33	18.65*	-40.34	25.46		
Simple chores make SOB	63.53	34.12	23.83	28.60	33.22	37.56		
BMI	-1.62	1.44	-3.23	2.05	-3.19	2.67		
Average daily sedentary time	R^2=0.0473	*p*=0.001	Not significant		Not significant		Not significant	
Years smoked	-0.38	0.71						
Age	0.02	1.14						
Sex	-33.08	18.78						
Total household income	0.00	0.00						
Simple chores make SOB	52.55	14.72**						
Average daily steps	R^2=0.3479	*p*=0.000	R^2=0.2464	*p*=0.000	R^2=0.5579	*p*=0.000	Not significant	
Years smoked	-33.50	19.62	0.28	41.71	0.78	30.36		
Age	-161.51	30.52**	-160.60	38.33**	-192.07	41.22**		
Sex	-2355.26	580.48**	-1742.18	937.58	-2902.06	736.28**		
Total household income	-0.00	0.01	-0.01	0.01	-0.00	0.01		
BMI	-157.66	44.40**	-198.81	68.15**	-210.86	85.35*		
Life satisfaction	-82.90	812.28	-2392.02	1092.16*	458.00	1104.99		

*$p<0.05$
** $p<0.01$

3.5 Discussion

According to the Canadian Health Measures Survey (CHMS), a large number of Canadians aged 35-79 years may be classified as having obstructive lung disease, with the majority of those falling into the mild obstruction category. At all levels of severity, exercise levels tend to fall below the recommended 150 minutes per week (30 minutes, 5 days per week) of moderate to vigorous physical activity for both adults and older adults (Canadian Society for Exercise Physiology, 2012), with the lowest level being in the severe to very severe obstruction category.

When examining the simple regressions from this study it can be found that percent of predicted forced vital capacity and percent of predicted forced expiratory volume in one second are predictors for most levels of physical activity except light PA, vigorous PA, and sedentary time in all levels of obstruction together. The relationship between percent of predicted FVC and physical activity may indicate that those whose lungs have a lower total volume than expected for their age, sex, height, weight, and race have lower levels of physical activity. The relationship between FEV_1 and physical activity is expected because lower FEV_1 indicates more obstruction and more obstruction means it is more difficult to actively exhale during physical activity. This leads to air trapping, and dyspnea with activity. When there is dyspnea with activity, an individual may avoid moderate to vigorous physical activity.

Respiratory symptoms are another frequent predictor in simple regressions with this Canadian population. Frequent, persistent colds were commonly associated with physical activity, especially in those with moderate airway obstruction. This is a new finding in the area of obstructive lung disease, although it seems natural to discover that those who self-report having more frequent, persistent colds would also have decreased physical activity because often, colds/acute exacerbations affecting those with obstructive lung disease can be very debilitating and lead to increased shortness of breath due to worsening airflow obstruction (Parker et al, 2005) and increased phlegm production. The symptoms of having a wheeze with exertion and simple chores making an individual short of breath are also fairly common predictors among physical activity measures in those with all levels of airway obstruction and moderate obstruction in this study. Again, this relationship is not unexpected as both of these symptoms could be considered unpleasant and lead to the avoidance of the trigger that causes them (physical activity). The relationship between wheeze on exertion and dyspnea and physical activity may be restricted mostly to those with moderate airway obstruction specifically because this is the stage of severity where a wheeze and increased levels of breathlessness start to impact an individual with COPD's daily activities (Fehrenbach, 2005). This then leads to a reduction in overall physical activity levels.

An individual's own perceptions on their health, mental health, and quality of life can also have an influence on physical activity levels. Self-perceived health was associated with all levels of physical activity except daily sedentary time and vigorous physical activity. It was one of the most common predictors across levels of severity as well. The finding that those with poorer perceived health is associated with lower physical activity levels is novel. This result is not surprising because individuals with poorer perceptions of their health have a tendency towards depression (Knowles et al, 2014), which is associated with decreased physical activity levels (Di Marco et al, 2014). Satisfaction with life in general was another common predictor for physical activity levels with lower satisfaction being related to lower levels of light PA, vigorous PA, total PA, sedentary time, and daily steps in those with all levels of obstruction and mild obstruction. In the general adult population, it has previously been found that the specific measure of life satisfaction is positively impacted by higher levels of physical activity and vice versa (Maher et al, 2015) but this has not been reproduced to my knowledge in the COPD population. Perceptions of quality of life were shown to be significantly related to daily steps, total daily PA, moderate daily PA, and moderate to vigorous daily PA in those with mild and severe to very severe obstruction with lower levels of quality of life being associated with lower physical activity levels. It is unknown why these two variables were related in only those with mild and severe to very severe obstruction and not those with moderate obstruction. The relationship between quality of life and physical activity levels is not a new one with previous literature finding that as physical activity levels increase in those with COPD, quality of life improves (Esteban et al, 2010). Self-perceived stress was also related to several types of physical activity in this population. Specifically, moderate physical activity, vigorous physical activity, and daily sedentary time but mostly in the category of all levels of obstruction together. Once again, physical activity levels went down as self-perceived stress went up. There was no published COPD specific literature looking at self-perceived stress and physical activity levels but in the general adult population, it has been found that as stress levels increase, physical activity suffers (Stults-Kolehmainen & Sinha, 2014).

Disability level encompasses various domains all together including physical, cognitive, sensory, and mental health. This was found to be significantly related to all of the physical activity domains included in this study in all levels of obstruction together. It has previously been found that physical inactivity is significantly related to an increased level of disability in those with COPD (Katz et al, 2011), therefore this result in the current study is a continuing validation of what has been previously investigated.

Grip strength as a measure of upper extremity strength and activity as well as partial curl ups completed in one minute as a measure of muscular endurance were found to be significant predictors among several of the activity levels. Grip strength was related to all physical activity variables except sedentary time and vigorous physical activity. This occurred mostly in the category of all levels of obstruction together but also frequently in those with severe to very severe obstruction and moderately frequently in those with mild and moderate obstruction. Previous literature has been split with respect to grip strength as a predictor of physical activity in those with COPD. One study found that there was no relationship between the two (van Gestel et al, 2012) while another study found that decreased grip strength was related to lower levels of physical activity (Nakamura et al, 2008). Partial curl ups completed in one minute was related to fewer physical activity measures than grip strength but was significantly associated with moderate and moderate to vigorous physical activity levels in all levels of obstruction together. There are no known articles that have investigated partial curl ups completed in one minute in relationship to physical activity levels in COPD, thus this is a potentially new finding in COPD research.

Age is a predictor for all physical activity levels, which is an instinctive result since physical activity tends to decrease as we age (Milanovic et al, 2013). Sex is also a common predictor for physical activity with lower levels of physical activity being more strongly related to being female. Once again, it has been previously demonstrated that women with COPD tend to have lower physical activity levels than men (Guenette et al, 2013) with women specifically having lower moderate physical activity levels than men (Park et al, 2014). Smoking history with total number of years smoked as a control variable was shown to be significantly related to all physical activity except vigorous physical activity and sedentary time. Body mass index (BMI) was also accounted for as a potential confounder and it was found that a higher BMI was related to lower physical activity levels, mostly in those with moderate airway obstruction in the following activity categories: daily steps, sedentary time, total daily physical activity, and light physical activity.

Generating a prediction equation for most physical activity variables was moderately successful where the highest variability accounted for with multiple regression when all levels of obstruction were included was 38.3% when predicting moderate physical activity. In mild obstruction the highest variance accounted for was with light physical activity (35.2%). There was slightly better variability accounted for with the moderate obstruction multiple regressions with the highest being in the moderate physical activity category (66%). There were no significant multiple regressions found for those with severe to very severe obstruction.

With daily light physical activity, it was found that after controlling for age, sex, years smoked, and total household income, that disability level, life satisfaction, frequent persistent colds, grip strength, and sit and reach values significantly helped to predict activity levels in those with all obstruction together, mild obstruction, and moderate obstruction. It was interesting to find that despite sit and reach values not reaching statistical significance in simple regression equations, it was found to be a significant predictor in multiple regression. The effect of flexibility appeared to be masked by confounders in the simple regression.

In daily moderate physical activity after controlling for age, sex, years smoked, total household income, arthritis, and diabetes the following also helped to predict activity levels: self-perceived health and self-perceived mental health. Similar to the variable of sit and reach distance in light physical activity, self-perceived mental health was not found to be significant in a simple regression but it was in multiple regression. This may mean that the effect of self-perceived mental health was also masked.

For daily moderate to vigorous physical activity after controlling for age, sex, years smoked, total household income and arthritis, the following variables helped to predict activity: simple chores make one short of breath, self-perceived mental health, and self-perceived quality of life. Once again, self-perceived mental health was found to be a multiple regression predictor but it was not significant in any of the simple regression analyses. The most likely reason for this is that it was being suppressed through confounding.

With respect to total daily physical activity levels after controlling for age, sex, years smoked, total household income, and BMI the following helped to also predict total daily physical activity: disability level and dyspnea with simple chores. Sedentary activity was predicted by dyspnea with simple chores after controlling for age, sex, years smoked, and total household income. Lastly, average daily steps was found to be predicted by satisfaction with life in general after controlling for age, sex, years smoked, total household income and BMI. These last three prediction equations did not contain any unexpected variables that increased the strength of the prediction.

There could be many other variables that could potentially account for physical activity levels that were not explored with the CHMS dataset. Things such as readiness to change, exercise self-efficacy (Delahanty et al, 2006), social support, facility access, and neighbourhood safety (Booth et al, 2000) are other predictors that have been used to help explain physical activity levels in older adults, which could also have relevance to this respiratory population. It is surprising from the multiple regressions that self-perceived health ended up not contributing significantly to very many of these analyses. This is interesting because it was such a common contributor to many of the simple regressions. This may be due to other variables confounding the relationship, leading to the awareness that self-perceived health may be more associated with variables such as age or sex than it is with physical activity levels themselves.

A limitation to this large data resource when looking at this specific population, is that adults over the age of 79 were not included. This may have increased the sample size even more and likely would have shown a larger number of those with more severe airway obstruction. While those who self-reported as having asthma were excluded from this study, it is still possible that some of those individuals who would be better classified as asthma rather than COPD were included in the analyses since self-report is only intermediately accurate (Leikauf & Federman, 2009) and no post-bronchodilator spirometry was completed. It is a strong benefit to the respiratory literature to have such a large sample size to examine from the Canadian population because it gives a more accurate representation of the physical activity levels of those suffering from airway obstruction, especially compared with previous studies whose sample sizes are significantly smaller. However, since the sample size was so large, it could have led to significance in some equations with a modest accounted for variance that may not have otherwise been significant in a smaller sample size.

3.6 Conclusions

Canadians with obstructive breathing patterns have lower than the recommended levels of physical activity, with more severe obstruction having the most reduced levels. After controlling for potential confounding variables, it was found that dyspnea from simple chores, frequent persistent colds, self-perceived health and mental health, quality of life, life satisfaction, disability level, grip strength, as well as sit and reach measurements were predictors for the various physical activity types in this obstructed airway population.

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Chapter 4 - Comparing Physical Activity and Mental Health Outcomes amongst Various Levels of Airway Obstruction: An Analysis of the Canadian Health Measures Survey

4.1 Abstract

Background: Individuals with COPD tend to have lower levels of physical activity than healthy controls with further decreases as level of obstruction increases. People with COPD also tend to have poorer mental health outcomes.

Objectives: The aim of this study was to examine data collected from a representative sample of Canadians to determine if people with obstructed breathing have lower levels of objectively measured physical activity and lower self-reported health and mental health than their non-obstructed counterparts. Comparisons will also be made between mild, moderate, and severe-very severe levels of obstruction.

Methods: Data from the Canadian Health Measures Survey was used to analyze differences in accelerometry measured physical activity of various intensities between those with obstructed breathing and those without as well as between levels of breathing obstruction. Self-reported physical health, self-reported mental health, and self-reported quality of life, along with several symptom measures were also analyzed.

Results: 4377 non-obstructed breathers (weighted n=28,190,961) had statistically significantly better self-perceived health than their 686 obstructed (weighted n=3,836,260) counterparts but no significant difference in physical activity levels. There were statistically significant differences amongst the various levels of obstruction with those having less obstruction having higher levels of moderate to vigorous PA and vigorous PA, better self-perceived health, higher stress, and higher QOL. Daily sedentary time was found to be lower in those with more severe obstruction.

Conclusion: There were no statistically significant differences in physical activity levels between those with obstruction and those without obstruction, however there is generally a decline in physical activity as level of obstruction increases. There is also a decline in self-reported health, QOL, and increased self-perceived stress as obstruction increases.

4.2 Introduction

Chronic obstructive pulmonary disease (COPD) is a non-reversible but also largely preventable respiratory impairment (O'Donnell et al, 2007). COPD is a disease that is widespread in Canada and can impact individuals both physically and mentally. COPD was responsible for approximately 4.4% of all deaths in Canada in 2011 (Bryan & Navaleen, 2015) with 4% of the Canadian population self-report having this disease (Public Health Agency of Canada, 2011). A more recent study (Evans et al, 2014) reported that 4% is an underestimation of the prevalence of COPD, stating that with pre-bronchodilator spirometry in the Canadian Health Measures Survey (CHMS), the prevalence is approximately 17% in Canadians aged 35-79 years based on FEV_1/FVC. In 2011, 45% of Canadians with COPD reported that their overall health was "fair or poor" and 15% said that their mental health was "fair or poor" with 28% reporting that most days were "quite a bit or extremely stressful" (Public Health Agency of Canada, 2011).

Quality of life, physical health status and self-perceived mental health are important measure in those with COPD. It has been found that quality of life decreases as the severity of the disease increases (Mewes et al, 2016; Negi et al, 2014; Jones et al, 2011; Balcells et al, 2010). Perceived health status has been shown to be low in those with COPD with diminishing levels as airway obstruction worsens (Boros & Lubinski, 2012). Poorer perceived health status is related to higher levels of disability in COPD (Rodriguez-Rodriguez et al, 2013) as well as a larger number of comorbidities, decreased levels of physical activity, and having a mental health comorbidity (de Miguel Diez et al, 2015). Mental health status has been previously implicated in increasing the risk of mortality in those with COPD (Stridsman et al, 2015).

People with COPD are less physically active than their healthy, age-matched counterparts (Watz et al, 2014). This reduced physical activity is associated with poorer general outcomes (Chambaneau et al, 2016). As the disease progresses, a decline in physical activity is often observed (Waschki et al, 2015). In addition to the reduced activity with disease progression, physical fitness also declines (Minikata et al, 2014) suggesting that the ability to participate in higher intensity exercise is reduced the worse an individual's obstruction is. This reduced level of physical activity in those with obstructed breathing is important because it is related to both mortality (Vaes et al, 2014; Garcia-Rio et al, 2012; Durheim et al, 2015; Blumenthal et al, 2016) and hospitalizations (Garcia-Rio et al, 2012; Durheim et al, 2015; Blumenthal et al, 2016;

Nguyen et al, 2014; Chawla et al, 2014). However, the risk of hospitalizations is dependent on the intensity of the physical activity with a reduction in the risk of hospitalization by 20% for every 1000 steps at a low intensity but not at a high intensity (Donaire-Gonzalez et al, 2015). Those with lower daily physical activity levels also have lower health related quality of life (Durr et al, 2014) and higher levels of anxiety and depression (Miravitlles et al, 2014). Determining the daily physical activity levels in those with COPD in Canada, broken down into various intensities and according to level of respiratory obstruction, has not been reported in a large, nationally representative sample.

As both mental health and physical activity are deeply impacted in those with obstructed breathing, it has been suggested that they may be codependent. Studies have found that pulmonary rehabilitation can improve symptoms of both anxiety and depression (Catalfo et al, 2016). An individual's level of depression, combined with their knowledge of self-management strategies has been found to impact physical activity levels as well (Schuz et al, 2015). Depression has also been known to impact an individual's functional status with increased depression being related to poorer physical function (Ng et al, 2009).

Since COPD is so prevalent in Canada, examining its impact on both physical activity, physical health, and mental health in a large, representative sample is of benefit to respiratory health care professionals. Therefore, the purpose of this study was to determine the difference between those with spirometry indicative of COPD and those without with respect to physical activity levels and self-reported physical and mental health. Differences in both physical activity and self-reported health and mental health measures will also be analyzed according to severity of obstruction (from mild to very severe obstruction).

4.3 Methods

Access was granted to the Canadian Health Measures Survey (CHMS) data (Cycles 1-3) through Statistics Canada at the Research Data Centre (RDC) in Saskatoon, Saskatchewan, Canada. Ethics approval is not required for RDC research projects as they have a rigorous screening process for who can complete research with Statistics Canada Data. Keeping the participants' personal and potentially identifying information confidential is important to the RDC so strict weighting procedures were essential as well as approval by a senior analyst of all data prior to release of any results from the RDC.

A cross-sectional sample is surveyed through the CHMS in order to collect general health data through both physical measures on and interviews with Canadians aged 3-79 years (Statistics Canada, 2014). Both urban and rural areas were sampled according to the population of the geographical area where they reside. Excluded from these samples were those living in institutions, members of the Canadian Armed Forces, and those living on reserves (Statistics Canada, 2014). Participants were recruited throughout five regions of the country (British Columbia [including Whitehorse], the Prairies [including Yellowknife], Ontario, Quebec, and Atlantic Canada) with the number of mobile clinic sites representing that area's population (Statistics Canada, 2014). National census data was used to select household members for participation based on their date of birth and requirements for age group participation with 1-2 members of each selected household being asked to participate (Statistics Canada, 2014). The sample selected to participate in the CHMS was limited to those within 50 km of the mobile clinics or within 75 km of the clinics in rural areas (Statistics Canada, 2014). Saskatchewan, Prince Edward Island, and the territories were not selected to have mobile clinic sites in any of the 3 CHMS cycles used in this study.

The CHMS data used in this study was collected from 2009-2013 throughout Canada using both household questionnaires as well as mobile clinic data. There were multiple cycles of data that were used and they were merged together into one data-set as they had the same weighting coefficient. Physical and self-report measures were collected regarding past medical history, general nutrition and fitness, past and present environmental exposures, along with previous encounters with potentially infectious diseases. Also, blood and urine samples were obtained as well as vital signs, spirometry, and anthopometric measures. Pre-bronchodilator spirometry was completed as part of the clinical testing. Spirometry is needed for a diagnosis of COPD with a ratio of forced expiratory volume in one second (FEV_1) to forced vital capacity (FVC) of less than 0.70 (O'Donnell et al, 2007). Mild COPD will have an FEV_1 ≥80% of predicted, moderate will be between 50-79% of predicted, severe is between 30-49% of predicted, and very severe has an FEV_1 of <30% (O'Donnell et al, 2007). This study examined adults over the age of 35 years and compared those with an obstructive breathing pattern (pre-bronchodilator FEV_1/FVC <0.70) to those without. The areas of comparison included physical activity measured by accelerometry as well as self-perceived mental and physical health, self-perceived stress, satisfaction with life, and self-perceived quality of life. Comparisons were also made using the same measures between multiple levels of airway obstruction including mild (FEV_1 ≥80% of predicted), moderate (50%≤FEV_1<80%), severe/very severe (FEV_1<50%), and no obstruction (FEV_1/FVC≥0.70).

4.3.1 Accelerometry

Actical activity monitors, along with written instructions for accelerometer use were distributed by CHMS clinic staff to eligible participants to be used over a seven-day period. Prepaid return envelopes accompanied the accelerometers for return to the CHMS researchers. All activity data was compiled into one file and only those individuals who completed at least one day of >10 hours of wear time were accepted. Data was recoded to show average daily light, moderate, and vigorous physical activity times as well as total physical activity, sedentary time, and number of steps taken per day.

4.3.2 Household Questionnaire Data

Specific measures of anxiety and depression were not used in the CHMS but self-perceived health and mental health were measured via 5-point Likert-type scales. The scale was condensed into 3 categories in order to have a large enough number of observations in each of the three categories of self-perceived health and mental health. These questions specifically pertained to self-perceived health, self-perceived mental health, satisfaction with life, and self-perceived quality of life. A simple question regarding self-perceived health or mental health has been shown to be reliable (Lundberg & Manderbacka, 1996) and can help to predict other physical, mental, and social variables (Ahmad et al, 2014). The use of a single item quality of life measure has previously been show to be reliable and valid in a respiratory population when compared to multi-item questionnaires (Yohannes et al, 2011). A single-item measure of self-reported stress (Elo et al, 2003) as well as life-satisfaction (Cheung & Lucas, 2014) have also been shown to be valid compared to multi-item questionnaires. See table 3.1 for these questions. Questions were also asked in the household questionnaire about smoking status, comorbidities, and disability level. Potential comorbidities included arthritis, diabetes, heart disease, and cancer. Disability level was measured by using the Disability Screening Questions (DSQ), which is a multi-question tool that evaluates disability based on four dimensions: physical status, cognitive status, sensory abilities, and mental health status (Grondin, 2016). The DSQ then categorizes people into four levels of disability including no disability, mild, moderate, and severe disability.

For the purposes of this study, this scale was dichotomized into those with no disability/mild disability and those with moderate to severe disability.

4.3.3 Mobile Clinic Data

Spirometry was race adjusted and completed with a Koko spirometer after both verbal instructions and a demonstration according to American Thoracic Society guidelines (Miller et al, 2005). A minimum of three acceptable trials were completed with each participant performing no more than eight trials. The best effort was determined by the summation of forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC). Post-bronchodilator spirometry was not completed. The Global Initiative for Obstructive Lung Disease (GOLD) criteria were used for spirometry (Global Initiative for Chronic Lung Disease, 2009), with the exception of not having post-bronchodilator spirometry. The NHANES III reference values were used in order to determine the upper and lower limit of normal values for spirometry (Hankinson et al, 1999). For this study, the Canadian Thoracic Society guidelines criteria for severity staging were used in separating the various levels of severity (O'Donnell et al, 2007).

4.3.4 Analysis

Analyses were run with Stata version 12 (StataCorp, 2011). Sampling weights were used to weight the data in order to approximate the Canadian population and account for the unequal probability of being selected to participate in the CHMS. Bootstrapping was used on all CHMS data to set both confidence intervals and standard errors. Statistical significance was set at $p<0.05$ for these analyses. Those individuals who self-identified as having a diagnosis of asthma were eliminated from the sample in order to attempt to have a sample that represents those with COPD only. The analyses were limited to those individuals 35 years and older and then divided into those with obstruction ($FEV_1/FVC <0.70$) and those without ($FEV_1 \geq 0.70$). A second division was also created categorizing different levels of obstruction (mild, moderate, severe/very severe, and no obstruction). Comparisons were made between those with and without obstruction according to the aforementioned variables using a simple regression. These analyses were used instead of a t-test or ANOVA because the statistical package used for the analysis would not allow these tests to be used with bootstrapping. For those divided according to level of obstruction, a simple regression was completed for each variable using Scheffe post-hoc testing to determine more detailed relationships. Multiple regression analyses were performed to control for age, sex, bmi, smoking status, total household income, disability level and comorbidities were potential confounders in the simple regressions. It was determined that an independent variable was confounded if these control variables were entered into the multiple regression equation and the beta coefficient changed more than 20%. Pearson's r was used to calculate effect size using the means and standard errors of the variables.

4.4 Results

There was a total of 5063 individuals included in this study with statistical weighting giving a population size of approximately 32 million people with a mean age of 53 ± 12 years. Approximately 12% of those individuals had pre-bronchodilator spirometry indicative of obstruction while 88% had no obstruction. Those without obstruction had a mean FEV_1/FVC of 0.78, a total daily physical activity of 217 minutes, and an average daily step count of 7326. Those with obstruction had a mean FEV_1/FVC of 0.64, a total daily activity of 212 minutes, and an average daily step count of 7197. Table 4.1 presents the characteristics of those with varying levels of obstruction.

Approximately 6.4% of the population studied had mild airway obstruction and were an average age of 58 years old with a mean percent predicted FEV_1 of 92%, had an average of 227 minutes of daily activity and took an average of 7828 ± 391 steps. Around 5.6% of this population had moderate to very severe airway obstruction with a mean age of 56 years, a mean percent predicted FEV_1 of 69%, an average of 180 minutes of daily activity with a mean number of steps of 6082 ± 369. Looking at those without airway obstruction, they had a mean percent predicted FEV_1 of 98% and an average daily step count of 7326 ± 118.

Table 4.1 – Subject Characteristics According to Levels of Airway Obstruction

Variable	No Airway Obstruction (mean±SE)	All Airway Obstruction (mean±SE)	Mild Airway Obstruction (mean±SE)	Moderate to Very Severe Airway Obstruction (mean±SE)
Weighted N Unweighted N	28,190,961 4377	3,836,260 686	2,048,069 390	1,788,191 296
Age (years)[acd]	52±0.19	57±0.69	59±0.94	56±0.44
Sex (% female)[ad]	51.91%	43.43%	40.62%	49.64%
Years smoked[acd]	18.31±0.44	24.84±1.47	21.74±1.19	25.87 ± 1.73
Total household income[acd]	80248±2365	64131±2531	68235±4759	65823±3321
BMI[abd]	28.00±0.20	26.78±0.06	25.94±0.33	29.26±0.31
FEV_1/FVC[abcd]	0.78±0.001	0.64±0.004	0.66±0.002	0.70±0.007
FEV_1 (% of predicted)[abcd]	98±0.30	80±1.23	92±0.75	69±0.62
FVC (% of predicted)[abcd]	98±0.32	95±1.00	106±0.66	78±0.83
Average Light PA (minutes)	203±2.96	202±7.86	214±9.10	174.47±7.44
Average Moderate PA (minutes)	15.10±0.57	13.59±1.38	16.29±1.67	9.87±1.26
Average Vigorous PA (minutes)[bc]	2.42±0.42	2.17±0.59	3.04±0.91	2.67±1.63
Average Mod-Vig PA (minutes)[c]	17.21±0.68	14.77±1.49	17.91±1.80	10.61±1.30
Total Average PA (minutes)	217.11±2.73	212.17±7.71	227.56±10.12	180.38±6.92
Average Daily Steps	7326±118	7197±321	7828±391	6082±369
Average Sedentary time (minutes)[b]	205±4	203±12	215±13	194.21±12.10
Self-perceived health (/3)[ac]	1.6±0.02	1.77±0.05	1.64±0.05	1.89±0.04
Self-perceived stress (/3)[ab]	1.8±0.02	1.7±0.04	1.6±0.04	1.71±0.06
Satisfaction with life (/3)	1.2±0.01	1.2±0.03	1.2±0.03	1.24±0.04
Self-perceived quality of life (/3)[a]	1.4±0.02	1.5±0.04	1.4±0.03	1.51±0.04
Self-perceived mental health (/3)	1.3±0.01	1.4±0.04	1.3±0.03	1.35±0.04

Disability level (/3)[a]	1.3±0.01	1.3±0.02	1.3±0.03	1.33±0.03
Cough regularly (% yes)[abc]	12.33%	26.25%	18.39%	24.83%
Cough up phlegm regularly (% yes)[acd]	9.82%	21.70%	20.24%	23.38%
Simple chores make SOB (% yes)[a]	9.43%	15.73%	7.68%	19.40%
Wheeze on exertion (% yes)[abc]	5.82%	14.74%	6.51%	19.17%
Frequent persistent colds (% yes)	4.14%	6.88%	6.07%	6.65%

(Significance set at $p<0.05$)
a – significant difference between no obstruction and all airway obstruction
b - significant difference between mild obstruction and moderate to very severe obstruction
c – significant difference between moderate to very severe obstruction and no obstruction
d - significant difference between mild obstruction and no obstruction

The following were found to be significantly different between groups with and without obstruction ($p<0.05$): self-perceived health, stress, quality of life, and the symptoms of coughing regularly, coughing up phlegm regularly, having a wheeze on exertion, and simple chores making one dyspneic. Self-perceived health and quality of life were more positive in those without airway obstruction while self-perceived stress was slightly more positive in those with all levels of airway obstruction than those without obstruction. All of the symptom variables were found to be significantly worse in those with all levels of airway obstruction compared to those without obstruction. Physical activity levels were not found to differ between those with obstruction and those without. Multiple regressions were performed again in order to control for the following confounders: arthritis, diabetes, disability level, years smoked, total household income, age, sex, and bmi. After controlling for these, only self-perceived health was found to still be significantly different between those with and those without obstruction. Please see Table 4.3 for percent change in **β**-coefficient after the addition of potential confounders.

When broken down into groups according to level of obstruction, it was found using multiple regression analyses to compare group means, that the following were significantly different between groups ($p<0.05$): average daily vigorous PA, average daily moderate to vigorous PA, average daily sedentary time, self-perceived health, self-perceived stress, the symptoms of coughing regularly, coughing up phlegm regularly and having a wheeze on exertion. Pairwise comparison scheffe testing showed that for average daily vigorous PA there was a significant difference between mild and moderate to very severe obstruction. These activity levels decreased as severity increased. For vigorous physical activity and moderate to vigorous physical activity, there was found to be a significant difference between those with moderate to very severe obstruction and those with no airway obstruction. Again, the physical activity levels decreased as airway obstruction increased. For total daily sedentary activity, there was also found to be a significant difference between those with mild and those with moderate to very severe obstruction with pairwise comparison scheffe testing indicating that those with moderate to very severe obstruction had less sedentary time than their mildly obstructed counterparts. Sedentary time was actually found to be lower in those with moderate to very severe obstruction. It was found that average vigorous PA was not significantly confounded by arthritis, diabetes, disability level, years smoked, total household income, age, sex, bmi but the moderate to vigorous PA and sedentary time were.

There were significant differences between those with moderate to very severe obstruction and no obstruction for self-perceived health with pairwise comparison scheffe testing. Pairwise comparison scheffe testing showed differences between mild and moderate to very severe obstruction for self-perceived stress with lower stress levels being associated with less severe airway obstruction. The variable cough regularly showed significant differences between those with mild and moderate to very severe obstruction and between those with moderate to very severe obstruction and no obstruction with pairwise comparison scheffe testing. The symptom of a regular cough was reported significantly more often in those with moderate to severe obstruction when compared with both those with no obstruction and those with mild obstruction. The variable coughing up phlegm regularly was significantly different between those with mild and no obstruction and between those with moderate to very severe obstruction and no obstruction. Again, this symptom was reported more often in those with mild to very severe obstruction when compared to those with no obstruction. For the variable measuring a wheeze with exertion, it was found that there was a significant difference between those with mild and moderate to very severe obstruction and between those with moderate to very severe obstruction and no obstruction. This symptom was increased as level of severity increased. After controlling for arthritis, diabetes, disability level, years smoked, total household income, age, sex, bmi, there was found to be no significant relationship between severity levels in the aforementioned variables.

Table 4.2 – Percent Change in β-Coefficient with the Addition of Potential Confounders

Variable	β-coefficient pre-control analysis	β-coefficient post-control analysis	Percent change in β-coefficient
Light PA			
COPD	-0.937	-4.680	-399.5
Severity	-11.552	1.554	-113.5
Moderate PA			
COPD	-1.515	0.314	-120.7
Severity	-1.413	0.406	-128.7
Moderate to vigorous PA			
COPD	-2.443	-0.407	-83.3
Severity	-2.349	0.013	-100.6
Vigorous PA			
COPD	-0.252	-0.409	-62.3
Severity	-0.537	-0.553	-2.98*
Daily Steps			
COPD	-129.014	88.357	-168.5
Severity	-142.641	331.578	-332.5
Daily Sedentary Time			
COPD	-2.043	-2.179	-6.7*
Severity	-9.200	-4.705	-48.9
Total PA			
COPD	-4.942	-0.710	-85.6
Severity	-2.286	4.703	-305.7
Self-perceived Health			
COPD	0.174	0.142	18.4*
Severity	0.152	0.098	35.5
Life satisfaction			
COPD	0.048	0.040	16.7*
Severity	0.050	0.039	22.0
Self-perceived Stress			
COPD	-0.140	0.029	-120.7
Severity	-0.013	-0.007	-46.2
Self-perceived QOL			
COPD	0.100	0.148	48.0
Severity	0.084	0.121	44.1
Cough Regularly			
COPD	-0.017	-0.139	-87.8
Severity	-0.129	-0.021	-83.7
Cough Up Phlegm Regularly			
COPD	-0.119	-0.027	-77.4
Severity	-0.105	-0.025	-76.2
Simple Chores make SOB			
COPD	-0.063	-0.018	-71.4
Severity			

Wheeze on Exertion COPD Severity	 -0.089 -0.082	 -0.040 -0.032	 -55.1 -61.0
Frequent Persistent Colds COPD Severity	 -0.027 -0.025	 -0.049 -0.045	 -81.5 -80.0

* Not confounded by age, sex, total household income, disability level, bmi, years smoked, arthritis, and diabetes

4.5 Discussion

The purpose of this study was to determine if there were differences in physical activity levels, general health (self-perceived health and self-perceived quality of life), mental health outcome measures (self-perceived mental health, self-perceived stress, and satisfaction with life), and respiratory symptoms (cough regularly, cough up phlegm regularly, wheeze on exertion, simple chores making one dyspneic, and frequent persistent colds) between those with various levels of obstructed breathing and those without. One of the most significant findings of this study is contrary to what many studies have found suggesting that physical activity levels in those with obstructed breathing are not different than those without.

This study, whose weighted sample size is approximately 32 million Canadians, showed that there was no significant difference in light, moderate, or vigorous physical activity, or time spent sedentary and number of steps taken per day between those with obstruction and those without. A review by Voorink and colleagues in 2011 explained that individuals with COPD have a decrease in objectively measured daily physical activity both in terms of duration and intensity when compared to healthy, age-matched controls. This was also the case in a study by Mador and colleagues in 2011. It has also been previously found that those with COPD spend a decreased amount of time walking, a shorter distance walked, a smaller number of steps taken per day than controls (Amorim et al, 2014), and a shorter time spent at all levels of intensity of physical activity (Minikata et al, 2014). However, there has been one past study that found no difference in the accelerometry data collected from patients with COPD and healthy sedentary control subjects (Gouzi et al, 2011). This study may have found this result because their healthy controls were considered sedentary instead of seeking out a more representative age-matched sample. In this study, if those with mild obstruction had physical activity levels closer to those with no obstruction, then this could have skewed the mean physical activity levels for all levels of obstruction together. This would mean that if there were a large number of individuals in the mild group that were very close to be considered to not have obstruction, they may have made it so the results showed no difference between the obstructed and non-obstructed group. The previously completed studies also had higher level of severity in their subjects than the current study with the majority of these studies having the mean severity falling into the severe category (FEV_1<50% of predicted). This could also help to explain why these studies found a significant difference but this study did not.

The comparison of habitual physical activity levels between the various levels of airway obstruction showed statistically significant differences that are more in keeping with the present literature where more severe obstruction is related to less activity. This was found to be the case with moderate to vigorous and vigorous daily activity but not with daily sedentary time. Those with moderate to very severe obstruction had significantly less moderate to vigorous physical activity and vigorous physical activity than those without airway obstruction. Those with mild obstruction had significantly more vigorous physical activity and sedentary time than those with moderate to very severe obstruction. Only vigorous physical activity maintained significance after controlling for confounders. This may indicate that the differences in levels of moderate to vigorous PA and daily sedentary time between these groups was likely due to one or more of the following factors: age, sex, years smoked, total household income, bmi, arthritis, diabetes, and disability level.

The results of this study provide confirmation of previous studies regarding physical activity in patients with COPD. A study by Eliason and colleagues in 2011 showed similar results with significant differences in time spent being moderately active between the healthy controls and those with moderate and severe COPD. Multiple other studies have also shown correlations between level of disease severity and amount of physical activity with physical activity decreasing as severity of obstruction increases (Minikata et al, 2014; Vaes et al, 2014; Garcia-Rio et al, 2012; Durheim et al, 2015; Miravitlles et al, 2014; Mador et al, 2011; Steele et al, 2011; Steele et al, 2013; Donaire-Gonzalez, 2013; Esteban et al, 2010). There is no known literature that has previously explored the differences in sedentary activity between levels of severity of airway obstruction. It would be expected that those with more severe airway obstruction would spend more time being sedentary than those with less obstruction as they would experience fewer symptoms such as dyspnea and wheeze if they were sedentary. This was not the case in this study. Previous research has only shown that those with COPD have significantly higher time spent in sedentary activities than their unobstructed counterparts (Hill et al, 2015), which was not confirmed by this study. One must be cognizant that these relationships were found to be confounded.

Examining the question of self-perceived health status yields results that would be unsurprising. It was found that there was a significant difference between those with no obstruction and those with obstruction as well as between those with no obstruction and those with moderate to very severe obstruction with worsening perceived health as airway obstruction increases. It has been shown in the past that those with COPD have a worse self-perceived health status than those in a control group, with those having a lower self-perceived health status also having a higher level of disability and suffering from some type of mental disease (Rodriguez-Rodriguez et al, 2013). Those with poorer health status also have increased rates of depression (Yohannes et al, 2016). Health status has been shown to significantly worsen as severity of disease progresses with those with the most severe obstruction having the worse self-reported health status (Azargoon et al, 2016). It has also been shown that there is only a difference in perceived physical health status and not mental health status between those with COPD and control group (Xiang et al, 2015; Stridsman et al, 2015), which was confirmed by this study. It is worth noting that the changes in self-perceived health across severity levels of airway obstruction were the only changes to remain significant after controlling for confounders.

The results for self-reported quality of life were also not unexpected. Quality of life was significantly higher in those with obstruction compared to those without airway obstruction. This relationship did not remain significant after controlling for confounders. Quality of life has been previously shown to be significantly lower in those with COPD as compared to healthy controls (Brown et al, 2010; Bhaskar et al, 2014). Health related quality of life (HRQOL) has been previously shown to significantly worsen along with disease severity in COPD (Mewes et al, 2016; Negi et al, 2014; Jones et al, 2011; Balcells et al, 2010) but this was not found in this study. Perhaps this did not occur in this study due to the recategorization to a 3-point scale to measure QOL from the original 5-point scale. When the number of response categories is reduced, so is the variability of the scale (Lozano et al, 2008), which means that there are less options to choose from and more of a chance that there will not be a significant difference between categories. Having worse outcomes with respect to health-related quality of life have been associated with increased levels of depressive symptoms, regardless of COPD severity

(Omachi et al, 2009). Another study also showed that worse HRQOL is associated with symptoms of both anxiety and depression (Balcells et al, 2010).

Sef-perceived stress is another measure that was found to be significantly different between groups. However, the direction of this relationship is surprising when looking at the relationship between those with and without obstruction. It was found that those with no obstruction had less self-perceived stress than those with obstruction. Previous research has found that there is no significant difference in life event stress scores (Lu et al, 2012). Otherwise there is very little literature examining the role of self-perceived stress as its own measure in those with COPD compared to those without or among various severity levels of COPD. More in line with expectations, it was also found that those with mild obstruction had lower stress levels than those with moderate to very severe obstruction. Again, there was no research found that supported this finding but one would expect that there would be higher levels of stress in those with worse airway obstruction (and therefore, worse COPD symptoms). It does need to be acknowledged that these aforementioned relationships were no longer significant after controlling for potential confounders. This may be why this result has not been previously reported as it may have been found to be confounded in other studies as well.

The presence of respiratory symptoms was found to be significantly different between many of the groups represented in this sample. The symptoms of a regular cough and having a wheeze on exertion were significantly different between those with and those without obstruction, between those with mild and those with moderate to very severe obstruction and between those with no obstruction and those with moderate to very severe obstruction. The symptom of regular phlegm production was significantly different between those with and without airway obstruction, between those without obstruction and those with mild obstruction and between those without obstruction and those with moderate to very severe obstruction. The symptom of dyspnea with simple chores was significantly different between those with and without obstruction. All of these symptoms were reported more often with increasing disease severity. There is little previous literature examining the changes in symptoms across levels of disease severity but what there is for publications shows a similar trend (Mackay et al, 2012) with increasing symptoms being related to increasingly impaired FEV_1 (Ghobadi et al, 2012; Papaioannou et al, 2014). Beyond just having increasing symptoms as disease severity increases, more respiratory symptoms are also related to increased number of acute exacerbations and hospitalizations (Varol et al, 2014). The symptom of phlegm production was one of the only symptoms that showed a difference between those without obstruction and those with mild obstruction. Previous studies have shown that the use of symptoms to assess COPD severity by way of the COPD Assessment Test has been shown to be sensitive to those with mild obstruction in addition to those with moderate obstruction and beyond (Gupta et al, 2016). Despite the obvious trend in increased symptoms with increasing severity of airway obstruction, confounders were shown to explain most of the variance between the severity groups.

There were several limitations to interpretation of the results of this study. Not having post-bronchodilator spirometry does not allow a diagnosis of COPD to be put on those with obstruction in this study as a post-bronchodilator spirometry result is required for this diagnosis (O'Donnell et al, 2007). Despite the exclusion of those with self-identified asthma, there may be those who have obstruction more consistent with asthma because of the lack of post-bronchodilator spirometry. Due to restrictions in release of information from the RDC, there was the inability to break the levels of airway obstruction down into further subcategories including separating moderate, severe and very severe obstruction. There could potentially be more significant relationships uncovered with a larger number of subcategories. Measures of self-perceived health, mental health, life satisfaction, and quality of life were measured by 3 point Likert-type scales instead of using validated questionnaires for each of the respective domains. This finding makes comparison to other studies more difficult when the same or similar questionnaires were not used and there were not multiple questions to determine a score on each domain. Despite making comparisons more difficult between studies, the use of single question items in the area of general health measures have been shown to be as valid, reliable, and sensitive as multi-item questionnaires (Macias et al, 2015). The specific use of single item questions regarding self-rated health (Lundberg & Manderbacka, 1996), mental health (Ahmad et al, 2014), life satisfaction (Cheung & Lucas, 2014), stress (Elo et al, 2003), and quality of life (Yohannes et al, 2011) amongst adult populations have been shown to be valid and reliable.

The current study also has major strengths to be mentioned. It used a large sample from the Canadian population, with weighted statistics in order to give a representation of those with obstructed and non-obstructed breathing within Canada. Having a study with a large sample size is important to ensure statistical analyses have adequate power. This study also used accelerometry as a measure of physical activity levels, which gives more objective data than self-report, questionnaires, or pedometer means of physical activity recording (Watz et al, 2014).

4.6 Conclusion

Contrary to the results of previous work, there was no significant difference in physical activity levels, as measured by accelerometry, between those with and without obstructed breathing. When looking at various levels of severity of obstruction, there was a decline in physical activity as severity of obstruction worsens but this result was confounded by age, sex, years smoked, total household income, disability level, bmi, and the presence of arthritis and diabetes. In general, self-perceived health, life satisfaction, and quality of life became more negative as respiratory obstruction increased and the prevalence of respiratory symptoms increases but all of these variables with the exception of self-perceived health were also confounded by the aforementioned variables.

4.7 References

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Chapter 5 – Discussion and Conclusions

5.1 Discussion

There are several main points to be taken from this body of work. First, physical activity in individuals with COPD is full of complexities and can be influenced by many different factors. These factors could potentially include but are not limited to anxiety, depression, illness perceptions, quality of life, and self-perceived health and mental health. Second, physical activity also has the potential to be impacted by self-perceived health, QOL, stress, mental health, life satisfaction, dyspnea, and other respiratory symptoms in COPD. Third, there may be differences in physical activity and measures of physical and mental health when breaking down level of obstruction into mild, moderate, and severe/very severe to compare with those having no obstruction. Those with fewer respiratory limitations appear to have less issues with self-perceived mental and physical health and tend to engage in higher levels of physical activity than those with more respiratory restrictions. Let us explore these findings a little closer and engage in a comparison between these findings and previous research.

5.1.1 Anxiety, Depression, Self-Perceived Mental Health, Self-Perceived Stress and the Relationship with Physical Activity

What has been learned from these research studies about the relationship between physical activity, anxiety and depression? The first study addressed this question in a pulmonary rehabilitation setting and found that both depression and anxiety did not impact physical activity levels (either habitual daily activity or submaximal exercise capacity). However, it was found that anxiety and depression were significantly correlated with self-rated shortness of breath during a six-minute walk test (p=0.019) and general dyspnea measured via MRC dyspnea score (p=0.005). The link between anxiety, depression and dyspnea as well as dyspnea and physical activity is well-established (Al-Gamal & Yorke, 2014; Borges-Santos et al, 2015; von Leupoldt et al, 2011; Doyle et al, 2013; An et al, 2010; Demeyer et al, 2016; Steele et al, 2000) so it is unknown why, since there were high levels of breathlessness, there was no significant relationship between physical activity, depression and anxiety. One potential reason for this aberrant result is that the scores for anxiety and depression on the HADS scale were actually within what is considered to be the “normal” category (0-7). When using the HADS, previous literature has found a range of 5.78 (Bentsen et al, 2013) to 9.41 (Al-Gamal, 2015) for anxiety scores and 4.55 (Bentsen et al, 2013) to 9.31 (Al-Gamal, 2015) for depression scores, meaning that the majority of individuals with COPD have been shown to range from having no anxiety or depression to mild anxiety or depression with this scale.

There are two potential reasons behind this non-significant relationship between anxiety and physical activity. They include a low number of subjects involved in the study as well as the reliance on self-report data for activity levels as opposed to more objective measures. Having a small number of subjects in a study can lead to a reduction in statistical power (Button et al, 2013), meaning that there is less of a chance that the study will be able to find a true effect. In general, higher levels of anxiety are associated with lower levels of physical activity (Teixiera et al, 2013). Interestingly, there is debate as to whether anxiety in a COPD population increases physical activity (Nguyen et al, 2013) or decreases physical activity (Schuz et al, 2015). Perhaps this is why the relationship was found to be non-significant in this study. As for the second concern with these findings regarding measures of physical activity, some of the study participants were able to use an accelerometer to obtain data on habitual physical activity levels but most relied on self-report due to a small number of available accelerometers. This was not optimal since it has been shown in a COPD population that self-report measures overestimate physical activity levels while accelerometers are more objective and accurate (Pitta et al, 2005; Steele et al, 2000).

The second study did not address the question of whether anxiety or depression specifically impact physical activity but did examine the interrelationship between self-rated mental health and physical activity. The question was posed to the respondent about how they would rate their mental health in general with the response ranging from excellent to poor. This study found that self-perceived mental health alone was not able to predict physical activity levels. However, when entered into a multiple regression equation, self-perceived mental health was found to help predict both average daily moderate physical activity as well as moderate to vigorous physical activity. There is little COPD literature on the vague descriptor of self-rated mental health. Most studies specify a type of mental health diagnosis or general quality of life so it is difficult to compare the results of this study to the existing literature. Since self-perceived mental health was not a significant predictor by itself but only in addition to other variables, it can be postulated that it works in conjunction with another variable in order to impact physical activity levels. Since it was not tested in this study, this theory cannot be confirmed.

Self-perceived stress was also used as a measure in both the second and third studies. Participants were questioned regarding the amount of stress in their lives and reflected on whether most days were stressful or not. It was anchored as not at all stressful to extremely stressful on a 3-point Likert-type scale. In the second study it was found that self-perceived stress was significantly related to moderate and vigorous daily physical activity as well as daily sedentary time. However, this did not maintain significance in any of the multiple regression analyses. In the third study it was found that stress perceptions were significantly different between those with and without airway obstruction as well as between those with mild and moderate to very severe obstruction. Those with mild obstruction had less stress than those with moderate to very severe obstruction but, interestingly, stress levels were actually higher among those without any airway obstruction when compared to those with all obstruction together. This was likely due to confounders that were controlled for in the study as the relationship was not maintained after confounders were entered into the regression equation. Life stress has previously been associated with symptoms of depression and poor health related quality of life (Lu et al, 2012). However, it has also been found that in situations researchers would expect to be stressful for COPD patients (hospitalization for exacerbation), patients' perceived stress was lower than expected (Medinas-Amoros et al, 2012). Overall, there is a lack of information on life stress alone in COPD, likely because most studies use measures of quality of life and stress may be included under this subheading.

5.1.2 Illness Perceptions and Their Relationship with Physical Activity

The results of this research indicate that there is no association between illness perceptions and physical activity in a small pulmonary rehab sample. There is not a large body of research in the area of illness perceptions and their impact on physical activity but what there is shows a relationship between increased six-minute walk distance and less perceived consequences, fewer emotional representations (Fischer et al, 2010), a less chronic perceived timeline and better illness coherence (Zoeckler et al, 2014). There was one study that examined illness perceptions and accelerometer recorded physical activity and found that, in general, more positive illness perceptions were related to increased habitual physical activity levels (Hartman et al, 2013). More specifically, those with severe and very severe COPD had higher physical activity levels associated with fewer perceived COPD consequences as measured by the Illness Perception Questionnaire while there were no associations in those with mild to moderate COPD (Hartman et al, 2013). Perhaps because this study group was considered to be in the moderate obstruction category instead of severe obstruction with a mean FEV_1 of 52% of predicted, this may be why illness perceptions were not related to physical activity levels.

The choice of which scale to use also may have influenced whether or not there was a significant relationship between exercise capacity or physical activity and illness perceptions. These studies used the longer version of the Illness Perception Questionnaire while the present study used the Brief Illness Perception Questionnaire in order to present less of a questionnaire burden to the study participants. Again, there is the problem of a small sample size with the current research study, which brings into question whether there is sufficient statistical power to be able to show a relationship if it exists. As was previously mentioned, the issue of a very small number using an accelerometer to objectively measure physical activity is raised, instead of all participants using self-report to record their daily activities. Further inquiry would be beneficial in order to have a more robust knowledge base surrounding habitual physical activity and how it is impacted by illness perceptions.

Despite not finding any correlation between illness perceptions and physical activity, there were significant correlations between anxiety and depression, along with the impacts scale of the SGRQ. Higher levels of anxiety and depression as well as a larger number of perceived impacts of COPD were related to more negative illness representations in this pulmonary rehab sample. Previous research has found similar results. Higher levels of anxiety and depression have been found to be related to a larger number of perceived COPD consequences and more emotional representations (Howard et al, 2009). In depression alone, it has been found that individuals with COPD experience an increased number of perceived consequences, a more chronic timeline, a stronger illness identity, less personal control and treatment control, more of an emotional response, and an increased number of concerns about their disease (Hyphantis et al, 2015). The impacts scale of the SGRQ is concerned with how social functioning is affected and whether there are any psychological troubles arising from respiratory disease (Jones & Ford, 2009). This is unsurprising, especially considering the previously mentioned correlation between illness perceptions and anxiety and depression. It is difficult to fully compare this study to previous research when previous studies have not used the same quality of life scale or have not broken down the scale into subscales. Only one study has used the SGRQ (Hoth et al, 2011) but did not break it down into subscales. Other previous research examining general illness perceptions and quality of life have shown that more negative illness perceptions are related to a lower health related quality of life (HRQoL) (Weldam et al, 2013; Tiemensma et al, 2016; Vaske et al, 2016).

5.1.3 Quality of Life, Satisfaction with Life and their Relationship with Physical Activity

The relationship between quality of life and physical activity was examined in both the second and third study. The question was asked of the respondent about how they would rate their quality of life. The answers were anchored from excellent at one end to poor at the other on a 3-point Likert type scale. The second study found that quality of life had several significant correlations with physical activity. Those with mild obstruction showed a significant correlation between QOL and moderate PA and those with mild and severe to very severe obstruction showed a significant correlation between QOL and moderate to vigorous PA. Also, those with severe to very severe obstruction showed a significant correlation between total daily PA and quality of life as well as between average daily steps and QOL. When self-perceived quality of life was entered into multiple regression equations it was only found to maintain significance in average daily moderate to vigorous physical activity. There has been some literature previously examining the relationship between physical activity and quality of life in this population. In general, it has been found that as physical activity levels in those with COPD increase, health related quality of life also increases with the inverse relationship also being true (Esteban et al, 2010). It has been previously found that number of daily steps is significantly related to quality of life with a higher number of steps being related to better QOL (Durr et al, 2014; Moy et al, 2009). Level of physical activity during an acute exacerbation is also linked to HRQoL with a decreased quality of life relating to decreased physical activity (Esteban et al, 2016). Use of interventions that improve physical activity in a COPD population also see an associated increase in HRQoL (Esteban et al, 2010). All of the mentioned studies have used quality of life scales validated for use in the COPD population. The loss of significance to quality of life in all regression equations except the prediction equation for moderate to vigorous PA in this study could potentially be because the use of a scale validated for use in COPD patients may be more sensitive to measuring quality of life than a Likert type scale. However, it has been shown that using a single question item to assess general health measures is as valid, reliable and sensitive as many multi-item questionnaires (Macias et al, 2015).

Participants in the second and third studies were also asked regarding their satisfaction with life in general with the same scale and anchors used as in the quality of life question. In the second study, life satisfaction was found to have a number of significant correlations with physical activity measures. In those with all levels of obstruction together, satisfaction with life was found to be related to light PA, vigorous PA, total daily PA, and daily sedentary activity. In those with mild obstruction, it was found to be significantly correlated with light PA, vigorous PA, total daily PA and average daily steps. When entered into multiple regression equations, satisfaction with life in general was found to maintain significance in the partial prediction of both average daily light PA and average daily steps. Life satisfaction was not found to be significantly different between any of the groups in the third study. There is no known literature examining the specific question of life satisfaction in relation to physical activity levels in those with COPD. However, there is a very small amount of research looking into this same relationship in an elderly population. In the healthy elderly, it was found that life satisfaction increases with increased levels of physical activity (Menec & Chipperfield, 1997). Physical activity has the capability of influencing life satisfaction regardless of age with higher levels of daily physical activity relating to improved satisfaction with life in general (Maher et al, 2015). Since life satisfaction has not been studied in the COPD population to my knowledge, there are no previously known relationships to compare the results of the third study to with respect to the differences between those with airway obstruction and those without.

5.1.4 Self-perceived Health and its Relationship to Physical Activity and Airway Obstruction

Self-perceived health was related to both physical activity levels in those with COPD as well as when level of airway obstruction was broken down into severity categories. A 3-point Likert type scale was used to measure self-perceived health with the question being asked regarding how the respondent feels their general health is. The reply has an anchor of excellent at one end and poor at the other end. It was found in the second study that self-perceived health had a significant relationship with number of daily steps plus all levels of physical activity with the exception of sedentary time. All severity groupings experienced a relationship between physical activity of some variety and perceived health. All levels of obstruction were impacted by self-perceived health in daily light, moderate, vigorous, moderate to vigorous, total physical activity, and daily steps. In those with mild obstruction, this relationship was found for moderate PA, vigorous PA, and moderate to vigorous PA. In those with moderate obstruction, the relationship was found in light PA, moderate PA, moderate to vigorous PA and daily steps. For those with severe to very severe obstruction it was only found in average daily steps. In multiple regression analyses, it was found to only maintain significance in its contribution to moderate physical activity.

When comparing these results to previous literature, there are no known studies breaking down the relationship into various levels of obstruction. In general, when looking at all severity categories of COPD together, studies show that a better self-rated health status is related to higher level of physical activity (Arne et al, 2011; Park et al, 2013; Miravitlles et al, 2014). This is confirmed by the findings of the current research. Poorer health perception has also been shown to be linked, not only to physical activity levels, but the amount of sedentary time an individual with COPD has in a day (Park et al, 2013). Health status is not only related to habitual physical activity levels but also physical performance in general with lower physical performance scores being associated with decreased perceived health status (Patel et al, 2014). An absence of physical activity completed during leisure time has also been found to be linked with a worse self-perceived health status (de Miguel Diez et al, 2015). Since previous studies have not already determined that the relationship health status has with physical activity may be significantly different based on varying levels of airway obstruction, this is a new contribution to the field of self-rated health.

In the third study, self-perceived health also had a relationship with level of airway obstruction. There was a significant difference in health status between those with obstruction and those without obstruction as well as between those with moderate to very severe obstruction and no obstruction. Self-perceived health was the only variable in the third study to maintain its significant difference between levels of obstruction after controlling for confounders. It has been previously found that self-reported health is significantly poorer in those with COPD compared to those without (Brown et al, 2010). Also, it has been found that health status does decrease as COPD severity increases, although there was no statistically significant difference between levels of obstruction (Waschki et al, 2015; Montes de Oca et al, 2009). However, it has also been found that there is lower than normal health status with all severity levels of COPD (Jones et al, 2011). Using the ADO index as a measure for COPD severity, there are findings that there is a significant correlation between the ADO index and health status (Zhang et al, 2014). The results of this study confirm what is already known in the area of self-perceived health.

5.1.5 Dyspnea and Other Respiratory Symptoms and their Relationship to Physical Activity and Airway Obstruction

In the first study in this series, there were no correlations found to exist between physical activity in this pulmonary rehab COPD population and shortness of breath, either during a 6-minute walk test or daily life. Previous studies have found this relationship to exist with increased levels of breathlessness being related to decreased physical activity levels (Demeyer et al, 2016; Steele et al, 2000; Watz et al, 2009). Air trapping can occur even at relatively low workloads in COPD (Loprinzi et al, 2015), which has the potential to result in decreased exercise tolerance due to shortness of breath. Those who experience air trapping and associated breathlessness during an exercise test also exhibit relative inactivity in the community (Loprinzi et al, 2015). Again, the reason behind the lack of significant correlation between breathlessness and physical activity in this study may be due to the aforementioned reasons of small sample size as well as insufficient objectively measured physical activity as compared to self-report.

The second study in this series examined dyspnea on exertion in the form of the self-report question regarding whether simple chores make them feel short of breath. This item was found to be related to light daily PA, moderate daily physical activity, moderate to vigorous daily physical activity, daily total PA, and daily sedentary time. All level of obstruction together showed a significant relationship between dyspnea and light PA, moderate PA, moderate to vigorous PA, total daily PA and daily sedentary time. Those with mild obstruction only had a significant relationship between moderate PA and dyspnea. Individuals with moderate airway obstruction showed a significant relationship between moderate PA, moderate to vigorous PA, and total daily PA. Simple chores making an individual feel short of breath was kept in several multiple regression equations as a significant predictor. It maintained significance in the multiple regression for moderate to vigorous daily PA, total daily PA, and daily sedentary time. In the third study, it was found that there was a significant difference between those with airway obstruction and those without for the variable of dyspnea with simple chores. It did not maintain significance after controlling for confounders. Dyspnea has previously been associated with physical activity levels with lower physical activity being related to higher levels of shortness of breath (Katajisto et al, 2012). It has also been shown to be significantly different between those with and without airway obstruction (van Helvoort et al, 2016, Lima et al, 2016).

Several other questions regarding respiratory symptoms were asked in the second and third studies. These questions include topics such as suffering from frequent, persistent colds and experiencing a wheeze with exertion. The question regarding frequent, persistent colds was found to be associated with light, moderate, moderate to vigorous, and daily total physical activity levels. Those with moderate obstruction showed a significant correlation between all of these physical activity levels and frequent persistent colds while those with all levels of severity together showed this relationship with moderate, moderate to vigorous and total daily physical activity levels and the symptom of frequent persistent colds. Multiple regression analyses found that frequent persistent colds maintained its significance only in the equation for average daily light physical activity. The third study found that the symptom of frequent persistent colds was not significantly different between levels of airway obstruction. This question is part of a series of questions that the Canadian Thoracic Society (O'Donnell et al, 2007) recommends physicians use to guide the use of spirometry to screen for COPD. No literature was found using this question to help screen for changes in physical activity levels. Individuals experiencing frequent, persistent colds may be part of the group of individuals who are frequent exacerbators. Those who experience frequent exacerbations tend to have an FEV_1 of approximately 46% of predicted (Miravitlles et al, 2015), placing them in the severe obstruction category. This sample with frequent, persistent colds impacted all levels of obstruction together and those with moderate obstruction so the relationship is not likely due to the frequent exacerbator subgroup. Further investigation into this specific question and its relationship to physical activity is required in order to fully understand this relationship.

The question regarding experiencing a wheeze from exertion is also a part of the 2007 Canadian Thoracic Society guidelines for managing COPD (O'Donnell et al, 2007). In the second study it was found to be related to light daily physical activity, total daily activity, average daily sedentary time, and daily steps for those with all levels of airway obstruction. In those with moderate obstruction the same relationships were found with the exception of daily sedentary time. There were no significant differences in a wheeze with exertion found between various levels of airway obstruction in the third study. No other literature was found to be associated with the question regarding having a wheeze from exertion helping to predict physical activity levels in COPD. It is curious that those with all airway obstruction together and moderate obstruction have a significantly associated wheeze with their physical activity. Is it only being picked up in the wheezing phenotype of COPD? The wheezing phenotype appears to be related to more severe airway obstruction (Huang et al, 2015), not moderate obstruction. This phenotype also experiences more exacerbations and their symptoms are worse (Huang et al, 2015). Perhaps there is a subsample of the group in this study that is being impacted by asthma instead of COPD. There is also the possibility of being a part of the asthma-COPD overlap subtype. It was attempted to control for this by eliminating those who self-identify as having asthma but it cannot be completely eliminated without the measurement of post-bronchodilator spirometry. Again, more research would be necessary to determine the mechanisms of this relationship.

Two other questions existed in both the second and third studies regarding having a regular cough and coughing up phlegm regularly. In the second study, these symptoms were not found to be significantly related to any physical activity measurement. It is unknown why there was not a relationship between the symptoms of cough or sputum production and physical activity levels were not found to be significant. Those individuals with COPD who have a higher level of cough and sputum production tend to fall into the category of chronic bronchitis. Those with chronic bronchitis tend to have a greater limitation in physical activity in comparison to those with similar airway obstruction without chronic bronchitis (Elbehairy et al, 2015). Potentially there is a different mechanism behind this difference in physical activity levels beyond chronic cough and mucous production.

In the third study it was found that there was a significant difference between those with and without airway obstruction, between those with mild obstruction and moderate to very severe obstruction and between those with moderate to very severe obstruction and no obstruction. The third study also examined the question of coughing up phlegm frequently. It was found that there was a significant difference in self-reported phlegm production between those with all obstruction together and no airway obstruction, between those with moderate to very severe obstruction and no obstruction, and between those with mild obstruction and no obstruction. Both of these questions and their relationship with level of severity of obstruction were found to be confounded by control variables. These questions are also part of a series of questions designed to screen for COPD using spirometry (O’Donnell et al, 2007). There has been an investigation that has compared subjective reporting of coughing between those with and without COPD and found a significant difference with those who have COPD coughing more frequently than those without COPD (Sumner et al, 2013). This same study also found that sputum production was a determinant of the presence and frequency of a cough in those with COPD (Sumner et al, 2013). One review article reported that both chronic cough and cough with sputum production are significantly more prevalent in those with COPD and are a risk factor for COPD acute exacerbations (Miravitlles, 2011). These symptoms and their relationship to AECOPD extends into those exacerbations requiring hospitalizations (Burgel et al, 2009).

5.1.6 Physical Activity According to Airway Obstruction

The third study in this series examined the differences in physical activity according to level of obstruction in the airways. The variables that had significant differences between groups were average daily moderate to vigorous physical activity, average daily vigorous physical activity, and average daily sedentary time. Post-hoc testing showed that for moderate to vigorous intensity activity, there were significant differences between those with moderate to very severe obstruction and those with no obstruction. The variable daily vigorous physical activity had post-hoc testing that showed that there were significant differences between mild and moderate to very severe obstruction and between moderate to very severe obstruction and no obstruction. The analysis of the variable average daily sedentary time showed with post-hoc testing that there were differences between those with mild and moderate to very severe obstruction with those with mild obstruction actually being more sedentary than those with moderate to very severe obstruction. The relationships with moderate to vigorous PA and sedentary time between levels of obstruction were found to be confounded by control variables. However, the relationship between vigorous daily physical activity and level of obstruction was not found to be confounded by control variables, and therefore, maintained significance.

In the third study in this series it was found that physical activity levels in each intensity level decreased as level of obstruction increased. This is confirming what has been found in extensive literature in the area (Waschki et al, 2015; Demeyer et al, 2016; Pitta et al, 2005; Blumenthal et al, 2016; Belza et al, 2001; Jehn et al, 2011; Nguyen et al, 2011; Steele et al, 2000). Breaking this down further, Jehn and colleagues (2011) found that time spent walking regular speeds, fast speeds, and number of daily steps was significantly different from one level of obstruction to the next with activity levels decreasing as obstruction increases. In terms of number of daily steps alone, Blumenthal and colleagues (2016) found that there was a significant difference between levels of severity but not necessarily descending in number as obstruction increases as they found GOLD level C actually took more daily steps than those in GOLD level B. Demeyer and colleagues (2016) found that not all levels of severity were significantly different from each other but that those in GOLD level 1 and 2 had significantly more steps per day than those considered to be GOLD level 3 and 4.

What is different from previous literature is that this study found no difference between those with obstruction (all levels) and those without. Prior studies have found that those with COPD have physical activity levels significantly lower than those without COPD (Vorrink et al, 2011; Pitta et al, 2005; Amorim et al, 2014; Chambaneau et al, 2016; Eliason et al, 2011; Kawagoshi et al, 2013; Mador et al, 2011; Nguyen et al, 2011; Hartman et al, 2013). These studies have generally had their mean FEV_1 (% predicted) in the severe obstruction range (<50% of predicted) with only one of the aforementioned studies having a moderate obstruction mean FEV_1. The mean FEV_1 for all airway obstruction together in this study was 78% which is at the high end of moderate obstruction, very close to mild obstruction. This may be why the only significant differences seen when comparing to those with no obstruction are with the moderate to severe/very severe obstruction groups. The other physical activity element that is different from previous literature is that daily sedentary time was actually lower in those with moderate to very severe obstruction when compared to those with mild obstruction. Previous literature has found differences in sedentary time between those with and without obstruction with those who have airway obstruction having a larger amount of time sedentary (Park et al, 2014). The only literature found examining sedentary behaviours and their relationship to COPD severity did not use accelerometry data but self-report data. This study found that sitting time increased as GOLD stage increased (Inal-Ince et al, 2014). It would be expected that if severity of airway obstruction increases and there are an increased number of respiratory symptoms, that sedentary time would rise. This may be potentially due to the symptom of dyspnea on exertion behing related to inactivity levels in COPD (Katajisto et al, 2012). Since it was found that sedentary activity was confounded by the control variables, this result is not surprising. It also could have been confounded by arterial stiffness (Sieva et al, 2015), muscle wasting (Shrikrishna et al, 2012), impaired muscular endurance (Serres et al, 1998), and leg fatigue (Todt et al, 2014).

5.1.7 Mental Health Measures According to Airway Obstruction

The third study inspected the differences in self-rated mental health between the various levels of airway obstruction. There was found to be no significant differences between any obstruction levels with respect to self-reported mental health. If drawing a parallel between self-rated mental health and other mental health diagnoses such as anxiety and depression, these results are different from what has been previously determined in the literature. It has been found that healthy controls have much lower levels of anxiety and depression than individuals with COPD (Di Marco et al, 2006; van Manen et al, 2002; Zhang et al, 2011; Mikkelsen et al, 2004). In terms of differentiating rates of mental health issues between levels of severity, Di Marco and colleagues (2006) found no significant difference among the various COPD severities. This was also found by Gudmundsson and colleagues (2006). Alternately, it has also been found that level of anxiety and depression (Zhang et al, 2013; Gherghesanu et al, 2016) as well as depression alone (Kim et al, 2014) are found to increase with increasing levels of COPD severity. Care needs to be taken in this interpretation since self-rated mental health is not equivalent to measures of anxiety or depression.

When trying to decipher the conflicting findings of the previous literature, a few items were inspected. All of the aforementioned studies had a fairly large number of participants, meaning that statistical power would not be an issue. The study by Kim and colleagues (2014) examined both BODE quartiles and FEV_1 alone to determine if worsening depression is related to increasing severity but only the BODE quartile showed the expected relationship and it embodies more than just FEV_1 but also body mass index, dyspnea, and exercise capacity (Celli et al, 2004). Gherghesanu and colleagues (2016) only described their findings as having anxiety and depression being found more frequently in those patients with severe COPD with little by way of numerical value to emphasize this relationship so it is unknown how strong this relationship is. Again, with Zhang and colleagues (2013), the ADO scale was used to show disease severity instead of FEV_1 alone where the ADO scale encompasses not only FEV_1 but also age and breathlessness (Puhan et al, 2012). Adding the extra variables as Kim and colleagues (2014) as well as Zhang and colleagues (2013) did may have impacted the result of their studies showing that anxiety and depression were related to COPD severity. The results of this study used percent of predicted FEV_1 to show severity as well as the studies by Gudmundsson and colleagues (2006) and Di Marco and colleagues (2006) so their results are more easily compared. In this light, the finding that there is a significant difference in self-rated mental health between mild and moderate to severe/very severe airway obstruction as measured by FEV_1 alone is novel. However, it is also difficult to draw definitive conclusions since the present study only used one 3-point Likert-type scale to measure mental health while other studies used validated scales to measure anxiety and depression.

The third study examined if there was a difference in self-perceived quality of life and airway obstruction and there were some significant relationships found. This study also used a 3-point Likert type scale to measure quality of life and it was analyzed to determine if there were differences according to airway obstruction. There were found to be significant differences between those with and without airway obstruction but not between various levels of airway obstruction. When comparing quality of life between those with COPD and those without, it has been previously found that individuals with COPD have poorer quality of life than their healthy counterparts (Xiang et al, 2015; Chambaneau et al, 2016; Moussa et al, 2016; Voll-Aanerud et al, 2008). Interestingly, there was no evidence in this study that QOL decreases with increasing airway obstruction. Previous research has shown that this is the case with a declining QOL relating to increasing airway obstruction (Lee et al, 2011; Blumenthal et al, 2016; Stahl et al, 2005; Amoros et al, 2009; Voll-Aanerud et al, 2008; Dhamane et al, 2016; Ekici et al, 2015; Kwon & Kim, 2016; Wu et al, 2015; Kim et al, 2014; Lin et al, 2014; Dignani et al, 2016; Negi et al, 2014; Azargoon et al, 2016). Blumenthal's study (2016) showed a percent of predicted FEV_1 of 45.3%, Stahl (2005) had a percent of predicted FEV_1 of 62%, Amoros (2009) had a percent of predicted FEV_1 of 38%, Ekici (2015) had a percent of predicted FEV_1 of approximately 63%, Wu (2015) reported percent of predicted FEV_1 of 53%, Dignani (2016) had a percent of predicted FEV_1 of 60%, Negi (2014) had a percent of predicted FEV_1 of 50% while Voll-Aanerud (2008), Kwon & Kim (2016), Kim (2014), Lin (2014), Azargoon (2016), and Dhamane (2016) did not report FEV_1 in their studies. This third study had an overall percent of predicted FEV_1 of 69% for all levels of airway obstruction together. This is higher than the aforementioned studies. This, along with the knowledge that the relationship was likely confounded, may be why there was a lack of significance between levels of airway obstruction with respect to self-reported quality of life.

5.2 Strengths and Limitations

This body of work had some limitations. One of these is that there is no representation of adults 80 years of age and older in any of the studies. This limits the gereralizability to the greater COPD population. It may also be a reason why there was less representation of those with severe to very severe airway obstruction, also limiting the greater generalizability. Another limitation, specifically in the second and third studies is the lack of post-bronchodilator spirometry. If this was included as a measure, a more confident diagnosis of COPD may be able to be given. Instead, there is potentially a number of individuals in the study with other types of airway obstruction such as asthma, despite the elimination of those with self-reported asthma.

Where there are limitations, there are also strengths. There is very little published research on the subject of illness perceptions and physical activity levels with the only study to be obtained finding that there was no impact of illness representations on physical activity levels (Weldam et al, 2013). The first study in this series looked at this as one of its outcomes and found similar results. Perhaps with an increased number of participants who all wore accelerometers, these results may have been different. One of the biggest strengths of the CHMS studies was being able to access a nationwide data-base in order to obtain a nationally representative sample of participants. This meant having a very large sample to work with and use weighted values to make sure the sample is even more representative of Canada's population. Having this large sample size also ensures adequate statistical power. The use of accelerometry in these studies is also beneficial as it gives an objective measure of physical activity. The data in these studies was collected by individuals who were trained according to the manual for the CHMS and followed a script when obtaining all information for the database. This ensures good interrater reliability for the data collected for these studies.

5.3 Recommendations for Current Practice

It may be useful to employ measures of self-perceived health when attempting to design an intervention for increasing physical activity levels. This research has shown that self-perceived health is significantly associated with physical activity levels and decreases as severity of airway obstruction increases. Knowing that an individual feels their health is severely impaired and that this may lead to decreased physical activity levels gives health care providers an opportunity for education on the subject. Being able to help them understand their diagnosis better may help them appreciate the benefits of increasing even light intensity physical activity.

Because mental health measures had an impact in multiple regression on physical activity levels, there is a recommendation to screen for anxiety and depression as they are prevalent in a COPD population and they get worse as severity increases. As mentioned earlier, previous literature supports the idea that anxiety and depression are associated with worse outcomes in COPD so if they can be treated it may lead to a better quality of life and physical outcomes for these individuals.

When asking patients regarding the presence of dyspnea with simple chores, a wheeze with exertion or whether they suffer from frequent, persistent colds, it is also important to ask regarding physical activity levels. Since there was an interaction between these questions and daily activity levels, there may be an intervention that can be offered by a physician or health care professional that will assist with both of these respiratory symptoms in order to help improve physical activity levels and other health outcomes.

Knowing that physical activity levels decrease as severity of airway obstruction increases, a recommendation for patients to monitor their physical activity levels may help them to know how active they are compared to how active they should be in order to decrease risk of exacerbation, increase their ability to perform functional activities, and improve their level of breathlessness. All of these will help to improve their overall mental health. There are an increasing number of ways to easily and accurately monitor physical activity levels in the general public. There are a high number of wearable technologies with the intended use of tracking daily steps more accurately than a pedometer and have been shown to be both valid and reliable in a COPD population (Vooijs et al, 2014). This has shown to be helpful for increasing physical activity levels among those with COPD (Caulfield et al, 2015).

5.4 Future Focus

Re-attempting a study similar to the first study in this series but with a much larger number of participants from pulmonary rehab would be beneficial to identify if those with anxiety, depression, or negative illness perceptions actually end up with less significant improvements in their physical outcomes such as 6-minute walk distance, daily physical activity levels, and dyspnea both at rest and during exertion. That was the intention of this project but recruitment and retention of participants was problematic. Having a longer time for recruitment would help to ensure a larger number of participants are involved in the study, which will increase the statistical power of the analysis. Similarly, more knowledge in the area of illness perceptions and their impact on habitual physical activity levels would also be beneficial. Presently there is limited knowledge in this area and, while the first study did touch on the topic, there was too few study participants to be able to draw any solid conclusions.

Self-perceived health as its own variable and its relationship with physical activity has only a small amount of research associated with it. Generally, it appears to be a part of quality of life measures but is not typically measured alone in those with COPD. Since it had a strong relationship with severity of airway obstruction but this has not been investigated with respect to physical activity levels before this series of studies, it would be fascinating to complete another study exploring how self-perceived health impacts physical activity levels according to level of obstruction and vice versa. The difference being, using post-bronchodilator spirometry to give a definitive diagnosis of COPD instead of a general diagnosis of obstructed breathing.

Further study of the subject of mental health measures (i.e. self-rated mental health, anxiety, depression) and how they change based on the severity of disease (as measured by FEV_1) alone would be beneficial as little has been done for research in this area. Since the previous literature is sparse in this area and the majority used multi-dimensional scales to determine severity instead of FEV_1 alone, it is difficult to draw conclusions in the area. Further, it will continue to increase knowledge in the area to investigate the comparison between multi-item severity scales such as the BODE index or ADO scale and FEV_1 to determine if the inclusion of other factors involved in disease severity are better at predicting mental health in COPD.

5.5 Conclusions

In a Canada-wide sample, it was found that self-perceived mental health was a significant contributor to moderate and moderate to vigorous physical activity levels in multiple regression analyses. The symptom of shortness of breath with simple chores was also found to be related to light, moderate, moderate to vigorous, total physical activity, and daily sedentary time in the CHMS sample.

It was found that physical activity levels vary by level of airway obstruction for average daily moderate to vigorous PA, vigorous PA, and daily sedentary time. All of these physical activity variables were found to diminish as severity of obstruction increased. However, daily sedentary time was actually lower in those with moderate to very severe obstruction. Frequent persistent colds were found to help predict daily light physical activity, moderate daily physical activity, moderate to vigorous physical activity, and total daily physical activity. Similarly, having a wheeze on exertion was related to light physical activity, total daily physical activity, average daily steps, and daily sedentary time.

Self-perceived quality of life was found to be significantly different between those with and without airway obstruction with worsening QOL being associated with those with obstructed breathing. Self-perceived stress was also found to worsen with worsening airway obstruction with significant differences between those with and without obstruction as well as between those with mild and moderate to very severe obstruction. Lastly, self-perceived health was also found to decrease as airway obstruction increases with significant differences between those with no obstruction and those with obstruction and between those without obstruction and those with moderate to very severe obstruction. It was also the only variable to not be confounded by other variables that were controlled for in the analyses.

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